OKLAHOMA GEOLOGICAL SURVEY
Charles J. Mankin, *Director*

CIRCULAR 84 **ISSN 0078-4397**

BASEMENT ROCKS IN NORTHEASTERN OKLAHOMA

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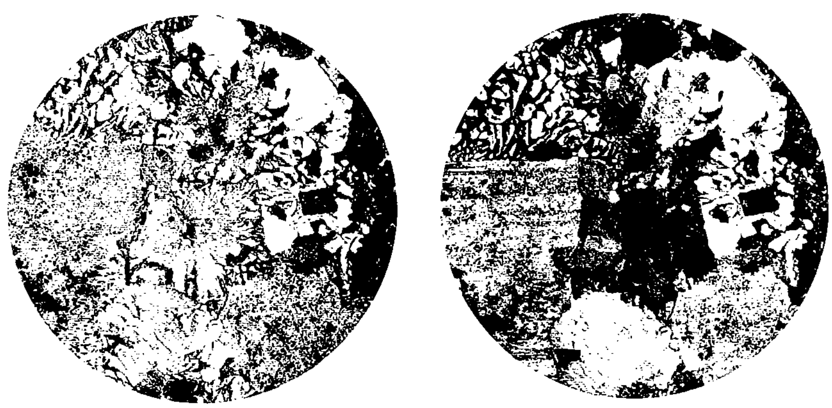

The University of Oklahoma
Norman
1981

Title Page Illustration

Photomicrographs of a thin section of Spavinaw granite from an outcrop in Mayes County, Oklahoma, showing a mantle of micropegmatite around oligoclase and free quartz. Diameter of the field is 4 mm. *Left*, ordinary light; *right*, crossed nicols. Photos by the author.

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BASEMENT ROCKS IN NORTHEASTERN OKLAHOMA

RODGER E. DENISON[1]

Abstract—Northeastern Oklahoma is underlain by Precambrian rocks that have been divided into four units on the basis of petrographic similarity. Available data are not sufficient to discriminate among these units on the basis of age. Rb/Sr tests indicate all the rocks to be about 1,300 million years old, and a single U/Pb zircon analysis dates them at approximately 1,370 million years. Three of the units—the Washington Volcanic Group, the Spavinaw Granite Group, and the Osage Microgranite—have the close petrographic affinity of an epizonal granite–rhyolite complex. These units are grouped into the Northeast Oklahoma Province. On the basis of geologic reasoning, the Central Oklahoma Granite Group is considered to have intruded the shallow granite-rhyolite complex. The rocks in northeastern Oklahoma were emplaced into granitic rocks to the north that are about 100 million years older. There is no evidence of older rocks to the south, and there is nothing known of the host.

The Northeast Oklahoma Province is one of a number of granite–rhyolite complexes that characterize the buried basement of the southern continental interior of the United States. The origin of these curious associations is not known, but they are not all of the same age, and they were clearly preserved in a broad synclinal sag.

The Washington Volcanic Group, consisting of rhyolite and minor andesite extrusive rocks, is the most widespread of the three units of the Northeast Oklahoma Province. Into this pile of volcanics two rock units were injected, probably as sills and irregular shallow intrusives. The Spavinaw Granite Group is composed mainly of micrographic granite porphyry and is found along a broad arch separating two large volcanic tracts. The Osage Microgranite is found in a broad domal area in Osage County, Oklahoma, and is composed of a highly uniform microgranite porphyry.

The Central Oklahoma Granite Group is probably the product of the same magmatic activity that gave rise to the Northeast Oklahoma Province. It is composed of coarser grained, two-feldspar granite that was evidently emplaced as a series of mesozonal batholithic intrusions and is interpreted as having intruded the epizone–volcanic suite. The intrusion of this unit is the last recognizable igneous activity in the area. The basement surface onto which the Cambrian and Ordovician seas transgressed was rugged, and much of the "structure" on the basement surface is actually drowned topography. This was later modified by warping and broad-scale movements in the late Paleozoic.

There appears to be some control of late Paleozoic movements by movements in the Precambrian, but in general there is very little structure, on a regional scale, in northeastern Oklahoma.

INTRODUCTION

Although the study of basement rocks in northeastern Oklahoma was begun in 1962 at the Oklahoma Geological Survey, most of the work was done at the Crustal Studies Laboratory of The University of Texas during the period 1962–64. The basic work was completed in 1966 and was submitted to The University of Texas in partial fulfillment for an advanced degree. The work described here includes examinations of numerous crucial well samples obtained between 1964 and 1977 (see Appendix), as well as various other additions and revisions.

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

Because of its comparative simplicity, the area under examination here is one of the most suitable for basement-rock studies. There are approximately 25,000 square miles in the area shown on plate 1 (pocket). 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 directly overlying the basement surface. Very few wells have penetrated more than 500 feet of basement rock, and, therefore, a three-dimensional picture is difficult to construct. (See the Appendix, Part 1, for a list of wells penetrating basement rock.)

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Precambrian rock is exposed in only one small area: the Spavinaw Granite, first described by Drake (1897), is exposed in five small hills near Spavinaw in Mayes County, with outcrops at an elevation of about 700 feet. Elsewhere, the granite is buried at depths generally less than 3,000 feet below sea level in the central area. The west and south margins of the area are somewhat deeper, particularly in the southern area, where the basement surface dips beneath the Arkoma Basin. In Le Flore and Haskell Counties, on the northern hinge line of the Arkoma Basin, the depth to basement exceeds 9,000 feet. The largest percentage difference in basement elevations is caused by relief in buried topography in areas where the basement is less than 3,000 feet deep. The largest differences in basement elevation are caused by late Paleozoic structural warps.

A small-scale map of the basement-rock distribution in this area was published by Muehlberger and others (1967, fig. 10), who in this brief account of the rock types, called the units the Osage County Microgranite and the Washington County Volcanic Group. I have decided to drop the "county" from the names for the sake of brevity.

County code numbers are used to cite samples from specific wells in the general descriptions. An example of this method of citation is Os-31, which indicates that the well is number 31 in Osage County. These numbers are used on plate 1, and in the Appendix.

Acknowledgments

The work on this project was begun in the early 1960's while I was working for the Oklahoma Geological Survey. Most of the petrography was done between 1962 and 1964, when I was working at the Crustal Studies Laboratory at The University of Texas at Austin, with funds supplied by the U.S. Air Force Office of Scientific Research as part of the Advanced Research Projects Agency project VELA UNIFORM under contract no. AF 49(638)–111S. A larger study that included northeastern Oklahoma was accepted as partial fulfillment for a Ph.D. degree at The University of Texas in 1966.

Dr. W. R. Muehlberger, of The University of Texas at Austin, was the director of the research project on basement rocks in the interior and of my dissertation. The late Dr. W. E. Ham and Dr. Louise Jordan, of the Oklahoma Geological Survey, worked closely with me on this project and spent many hours in discussions and collection of data. Some of the samples were collected by W. H. Bellis and T. L. Rowland, then with the Oklahoma Survey. The late John F. Roberts, of the Oklahoma Survey, collected numerous samples that became available after the original study had been completed. Ernest Hetherington of Mobil Research and Development Corp., Dallas, helped with the evaluation of the isotope data and the calculation of isochrons.

The original manuscript was reviewed by Dr. M. E. Bickford of the University of Kansas and Dr. E. G. Lidiak of the University of Pittsburgh. Mrs. Betty Ham carefully edited the final manuscript and brought to it whatever consistency it enjoys. The illustrations and maps were prepared by Zack T. Morris and T. Wayne Furr. Drs. K. S. Johnson and K. V. Luza offered suggestions for substantial improvement of the maps. Finally, the study has had the consistent support of the Oklahoma Geological Survey, Dr. Charles J. Mankin, director.

PETROGRAPHY AND ROCK UNITS

Northeastern Oklahoma is underlain by rocks that can be divided into four major Precambrian map units. These are defined on the basis of petrography as determined from examination of well samples. These rocks were extruded and intruded within a narrow time interval that cannot be delimited on the basis of available isotopic ages, although perhaps several of the rock units could be subdivided if there were more samples available or if the wells were more closely spaced or evenly distributed.

Three of these 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 three petrographic units form the Northeast Oklahoma Province, a petrographic grouping of rhyolite and hypersolvus epizonal-type granites. Eighteen rubidium–strontium ages have been determined on widely separated samples from this province; 16 are from within the study area. The best age is 1,286 ± 18 million years on the basis of a least-squares-fit isochron. The units have been placed in a relative age sequence as follows, from oldest to youngest, with determinations made on the basis of petrographic and geologic evidence:

Washington Volcanic Group

The Washington Volcanic Group is composed mostly of rhyolite, but andesite occurs in certain areas. The volcanic rocks were extruded over a large area as a sequence of flows and tuffs. The rhyolite was converted to metarhyolite in a wide area around the margin of the Northeast Oklahoma Province.

Spavinaw Granite Group

The Spavinaw Granite Group is composed mainly of micrographic granite porphyry that is 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 are found in drill holes along a broad pre-Paleozoic arch extending from southwestern Missouri to central Oklahoma. The group includes strongly femic and sparsely femic granites.

Osage Microgranite

The Osage Microgranite underlies 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.

Central Oklahoma Granite Group

One rock unit is interpreted on petrographic evidence and geologic reasoning as being younger than the rocks of the Northeast Oklahoma Province:

The Central Oklahoma Granite Group is a medium-grained, two-feldspar granite such as is typical of mesozonal emplacement. Eleven fractions from six samples of granite have been dated, and all are on a 1,277 ± 42-million-years Rb/Sr isochron. Thus, this group is probably a product of the same magmatic episode that gave rise to the Northeast Oklahoma Province.

Boundaries between Units

The contacts between rock units shown on plate 1 are a combination of geologic boundaries that are based on petrography of well samples plus extrapolations of these units in areas with no control, using regional gravity and magnetic data. The present delineation of the contacts must await future drilling for substantiation.

An example of this extrapolation by using gravity and magnetic maps is the contact between the Spavinaw granites and the rocks of the Central Oklahoma Granite Group in the Lincoln County area. Here, there is no control except for one well that penetrates Spavinaw-type granite in the northeastern corner of the county. However, there is a large negative magnetic and gravity anomaly in the center of the county, and the coincident limits of the anomalies are used to extend the limits of the Spavinaw granites beyond that of the well control.

The boundaries between the volcanic rocks and the Spavinaw granites are shown as straight, smooth contacts. However, because of the probable low dip of the granite-rhyolite contact, the actual contact must be highly irregular, owing to substantial local relief and differential erosion. Where the contacts are best defined in southern Osage and Delaware Counties, they show considerable complexity. But where control is sparse, the boundaries are of necessity straight and smooth.

ISOTOPIC AGES

Twenty-four Rb/Sr ages have been determined on samples from northeastern Oklahoma (Muehlberger and others, 1966; Denison and others, 1966 and 1969). One additional published determination from adjoining McDonald County, Missouri, was used in the calculation of the isochrons. Zircons from the Spavinaw Granite outcrop have been dated by Bickford and Lewis (1979).

All published ages have been recalculated (table 1) using the 48.8-billion-year half-life for Rb^{87} (λ_β = $1.42 \times 10^{-11}/yr^{-1}$). The errors cited are derived from the published analytical precision for isotope dilution and ratio measurements, and the error in the calculated initial ratio from isochron calculations. The isochrons from the Rb/Sr determinations yield reasonably small errors in slope and initial ratio determinations. The initial ratios from each of the unit isochrons fall into the range 0.704 ± .001, a typical value for undisturbed igneous rocks in this age range. The results are remarkably consistent when it is considered that whole rocks, feldspar, and biotite from samples obtained over an exceptionally large area were used in the determinations.

The calculated age and intercept for the three rock groups and all samples are presented in table 2. The isochron plot is shown in figure 1. The two determinations from the Osage Microgranite are not considered sufficient to calculate a meaningful isochron, but the determinations fall on the isochron generated by all points. The best Rb/Sr age for all units is considered to be that calculated using all determinations, 1,286 ± 18 million years. Of the 25 ages, only four fall outside the error of the isochron: three are younger, and one, older.

One U/Pb zircon age from the Spavinaw Granite outcrop yields a concordia age of 1,370 ± 20 million years (Bickford and Lewis, 1979). There is therefore an 84-million-year difference between the best Rb/Sr age and the U/Pb data (or 46 million years if the maximum errors are used). The data cannot be treated to resolve the discrepancy.

Certainly the Rb/Sr ages are a mixed bag. The samples chosen and the methods and techniques used in the determinations are not those that would necessarily be used today. Nevertheless, it is believed that the basic results would not be changed significantly if the work were redone from scratch. The available results show no evidence of later thermal disturbance, a potential cause of the discrepancy (compare the Rb/Sr data of Bickford and Mose, 1975, from the St. Francois Mountains).

It is believed that the discrepancy is systematic. In order to correlate the Precambrian rocks in northeastern Oklahoma with other areas, one must take into account the method for dating and the decay constants used in the calculation.

TABLE 1.—ISOTOPIC AGES ON BASEMENT SAMPLES FROM STUDY AREA

Operator and farm	County and location[1]	Age—millions of years[2]	Reference[3]	Depth (ft) and sample type	Rock group
Hembree C-3 Hembree	Pottawatomie 19-7N-5E	1192 ± 24 F	2	7755-7775 cuttings	Central Oklahoma Granite Group
Pan American 1 Tackett	Le Flore 28-8N-23E	1239 ± 52 F	1	9248-9272 core	Central Oklahoma Granite Group
Pawnee Petr. 1 Rentie	Seminole 23-9N-6E	1242 ± 21 F	3	7261 cir. cuttings	Central Oklahoma Granite Group
Cities Service 5 Farley	Oklahoma 19-11N-2W	1220 ± 73 F	1	8275-8300 cuttings	Central Oklahoma Granite Group
Oklahoma Nat. Gas 1 Stockton	Sequoyah 20-11N-26E	1246 ± 67 W	1	6145-6146 core	Washington Volcanic Group
Central Commercial 3 Hay	Creek 10-17N-10E	1212 ± 48 W	1	4250-4282 cuttings	Spavinaw Granite Group
Henderson 1 Kelly	Wagoner 18-17N-17E	1281 ± 38 W	3	2500-2505 cuttings	Washington Volcanic Group
Henderson 1 Carter	Mayes 26-19N-18E	1299 ± 26 W	3	2005 cir. cuttings	Washington Volcanic Group
Texaco 1 Osage "C"	Osage 24-20N-11E	1286 ± 24 W	3	2685-2690 core	Washington Volcanic Group
Amax DAC-2	Delaware 6-20N-23E	1270 ± 32 F	3	1704 core	Washington Volcanic Group
Amax DAC-3	Delaware 23-20N-23E	1303 ± 24 F	3	947 core	Spavinaw Granite Group
Sinclair Oil & Gas 46 Jones	Pawnee 20-21N-8E	1224 ± 51 W	1	2944 core	Washington Volcanic Group
Smith & Daniels 2 Vierhiller	Rogers 36-21N-16E	1247 ± 61 F	1	2701-2787 cuttings	Spavinaw Granite Group

Norbla Oil 2 Lyman	Osage 24-22N-9E	1281 ± 48 F	1	2972 cir. cuttings	Osage Microgranite
Amax SP-2	Mayes 8-22N-20E	1317 ± 22 F	3	1816 core	Spavinaw Granite Group
Spavinaw Granite	Mayes 15-22N-21E	1326 ± 58 F 1370 ± 20 Z	1 4	Outcrop	Spavinaw Granite
Oklahoma Nat. Gas 1 Hardrow	Noble 15-23N-2W	1381 ± 29 W 1329 ± 26 F 1318 ± 21 B	2	5508 cir. cuttings	Central Oklahoma Granite Group
Porter Oil & Gas 20 Miller	Pawnee 33-23N-3E	1312 ± 57 W	1	4686-4691 core	Washington Volcanic Group
Cities Service 1-SWD Osage Lot 292	Osage 8-24N-11E	1233 ± 50 W	1	2804-2821 cuttings	Washington Volcanic Group
Texaco 16 W. S. Kohpay	Osage 29-25N-8E	1183 ± 46 W	1	2845-2846 core	Osage Microgranite
Anderson Prichard 28 Welch	Kay 17-28N-1E	1228 ± 56 W 1260 ± 51 F	1	4406-4407 core	Central Oklahoma Granite Group
Amax HC-1	McDonald 27-21N-33W (Missouri)	1253 ± 26 F	3	1920 core	Spavinaw Granite Group

[1] Locations are in Oklahoma, except where noted.
[2] W, whole rock; F, feldspar; B, biotite; Z, zircon.
[3] 1. Muehlberger and others (1966).
2. Denison and others (1966).
3. Denison and others (1969).
4. Bickford and Lewis (1979).

$\lambda_\beta = 1.42 \times 10^{-11}$/yr.

TABLE 2.—RESULTS OF RUBIDIUM/STRONTIUM ISOCHRONS

Rock unit	Age (m.y.)	Initial Sr^{87}/Sr^{86}
Washington Volcanic Group	1282 ± 15	0.7043 ± .0005
Spavinaw Granite Group	1277 ± 38	0.7045 ± .0021
Central Oklahoma Granite Group	1277 ± 42	0.7055 ± .0028
All determinations	1286 ± 18	0.7043 ± .0008

$Rb^{87}\lambda_{\beta} = 1.42 \times 10^{-11}/yr^{-1}$.
Isochron program from York (1966).

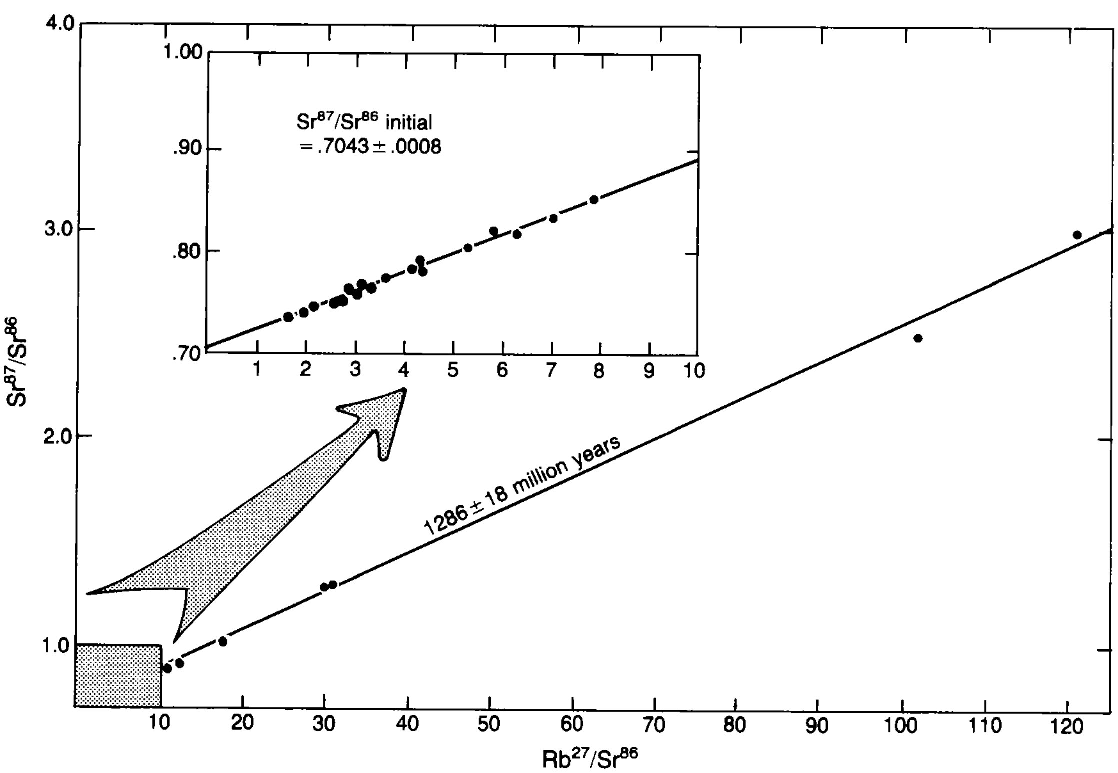

Figure 1. Isochron plot of all Rb/Sr determinations.

NORTHEAST OKLAHOMA PROVINCE

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

Eighteen Rb/Sr age determinations on rocks from this province all fall into a relatively narrow range of about 1,285 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 evidence. The sequence is based, rather, on analogies with well-known outcrop areas and geologic reasoning.

There are several significant differences between the Northeast Oklahoma Province and the Wichita Province of Cambrian age in southern Oklahoma:

1. A generally less siliceous composition for the bulk volume of the northeastern rocks.
2. Diabasic dikes and sills are exceptionally common in the rhyolites and granites of the Wichita area and are conspicuous by their absence in northeastern Oklahoma.
3. The Wichita Province contains, in addition to granite and rhyolite, a layered gabbroic mass, a basalt–spilite sequence, and metasedimentary rock. All of these are lacking in the northeast.

The rocks of the Northeast Oklahoma Province 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 represent a deeper erosional level in the basement complex owing to more extensive uplift, with subsequent erosion.

The Northeast Oklahoma Province is but one of a broad, segmented band of epizone granite–rhyolite complexes that stretch from western Ohio to far west Texas (Muehlberger and others, 1966, 1967; Lidiak and others, 1966). Although they are of different ages, there is some overlap between parts of the activity that gave rise to these complexes. There is a general trend for a lowering of ages toward the southwest. However, the youngest of the granite–rhyolite associations, the Wichita Province of southern Oklahoma, is of Cambrian age and is near the middle of the band. The origin of what is now a linear band of complexes is unclear. They must, however, owe their preservation to a structural low or sag that allowed these stratigraphically high rocks to escape erosion.

Washington Volcanic Group

Introduction

A large part of northeastern Oklahoma 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, metarhyolite, and andesite. Rhyolite porphyries and their equivalent tuffs are by far the most common and widespread rock type. Andesite is found in an area in Craig and Ottawa Counties, Oklahoma, and an immediately adjoining area in Labette and Cherokee Counties, Kansas. The andesites are not mapped separately on plate 1. The metarhyolites occupy a broad subsurface band essentially between normal rhyolite and the Central Oklahoma granites.

The volcanic rocks occur in two large tracts and a small one. The area north of the Spavinaw Granite is referred to here as the northern tract, that south of the Spavinaw Granite as the southern tract, and the smaller area totally surrounded by the Spavinaw Granite in Wagoner and Mayes Counties as the central tract.

The volcanic rocks cover a large area. About 15,000 square miles in northeastern Oklahoma and adjoining states are estimated to be underlain by rocks of this unit. Owing to a lack of control, the boundary to the south and east is not defined. An estimated two-thirds of the area is underlain by rhyolite, slightly less than one-third by metarhyolite, and less than 2 percent of the area is believed to be underlain by andesite. The topographic relief on these volcanic rocks exceeds 1,500 feet in a single township. With this much relief it is difficult to infer an average thickness of less than half a mile for the volcanic rocks over this large area, and estimates of a mile or more are probably more appropriate in some localities. The volume of rhyolite and related rocks in Oklahoma is thus on the order of 5,500 to 11,000 cubic miles. This is the estimated present area and volume after extensive erosion and does not include contiguous rhyolites outside northeastern Oklahoma.

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 westward to eastern New Mexico. The rhyolite in Missouri is clearly older than those in Oklahoma, and those in the Texas Panhandle are slightly younger (Muehlberger and others, 1966; Bickford and Mose, 1975).

Although the areas are not now continuous, they may have been part of a single complex rhyolite field before being subjected to about 700 million years or more of erosion prior to the transgression of Cambrian seas.

The maximum drilled thickness of rhyolite in the study area is 475 feet in the Empire Gas & Fuel 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 are no reliable published estimates. The volcanic rocks in the Texas Panhandle have a drilled thickness (base not reached) of 3,449 feet in the Whittenburg 1 Whittenburg in southern Carson County.

In order to distribute silicic volcanic rocks over such a large area, an ignimbritic origin is reasonable to postulate for a substantial part of the sequence, even though the petrographic evidence for an ash-flow origin cannot be demonstrated in most of the samples examined.

Isotopic Age

The age of the Washington Volcanic Group is indistinguishable from other rock units in the Northeast Oklahoma Province. The isochron age of 1,282 ± 15 million years on nine samples of rhyolite is well within error of the 1,286 ± 18-million-year Rb/Sr age for the province as a whole. The calculated initial Sr^{87}/Sr^{86} for rhyolite is 0.7043 ± .0005. No andesites were dated. Of the nine samples dated from this group (eight within the study area), three were metarhyolites.

Petrography

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.

Perthite constitutes an average of about 8 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 have subhedral or euhedral outlines locally, but complete rounding of these composite phenocrysts is more common.

In one sample from the Empire 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 of the majority of the rhyolites.

Perthite phenocrysts are generally clouded with hematite dust and minor alteration products. 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, which is reduced to a semi-opaque mat of generally indeterminate clay–mica alteration minerals. The average length of the perthite phenocrysts is about 5mm, but composite phenocrysts about 1cm 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, patches of sericite, clay-zeolites, and epidote suggest a pseudomorphic replacement of original plagioclase. The composition is generally intermediate albite to intermediate oligoclase, and rarely is more calcic than An_{30}. 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. 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 those of the perthite.

Quartz phenocrysts make up an average of about 2 percent of the rock volume. These phenocrysts account for as much as 12 percent in rare samples but are absent in over a third of the rhyolites examined. 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 modify an otherwise euhedral form. The average size of the quartz is less than that of the feldspars, ranging between 1 and 2 mm in diameter.

Magnetite–ilmenite granules are found as smaller, less numerous phenocrysts and in many rhyolites. Ilmenite is commonly replaced by sphene–leucoxene, and more rarely magnetite is replaced by hematite. Partial or total inclusions of apatite and zircon in the iron ores are not uncommon. The size of these phenocrysts is generally less than 1 mm.

In general, relicts of former femic minerals are rarely found as phenocrysts. Small amounts of pyroxene occur as a primary femic mineral in rhyolites of the central tract (Wg-3 and Wg-4). The pyroxene occurs as relicts within chloritic masses and accounts for nearly 2 percent of one sample examined. Either chlorite or a complex mixture of sericite–muscovite, secondary biotite, and opaque minerals now replaces 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.

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 that 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 abundant 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, whereas others appear to have been crystallized initially without having passed through a glassy state. The groundmass is composed essentially of quartz and feldspar, but the amount of quartz appears to vary considerably. The groundmass is generally reddish to tan as a result of the presence of hematite and limonite. In samples collected directly below the overlying sediments in a number of wells this color is leached, leaving the rhyolites a dull gray color.

Devitrified rhyolites are locally conspicuously banded, even in fine well cuttings (see pl. no. 3). 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 contain spherulites, and 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. 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 uncommon even in the strongly banded former glasses.

Rhyolites that apparently did not pass through a vitric phase, or were devitrified under the influence of heat and vapor soon after extrusion, are most commonly felsophyric in texture. The quartz is intimately and randomly intergrown with feldspar, and part of the quartz has a delicate rodlike appearance in thin section. Locally this texture is gradational with other types. Vague spherulites, together with fine, acicular quartz, are common in parts of the felsophyric texture.

Two wells in Osage County (Os-11 and Os-34) penetrated a rhyolitic arkose as the sole basement-rock type. These rocks contain poorly to moderately sorted sand-sized clasts composed almost entirely of rhyolitic debris. Most clasts are derived from rhyolite groundmass displaying diverse textures. The crystal clasts are mostly derived from phenocrysts. A few clasts of microline suggest that a granitic source was a minor contributor in one of the wells (Os-11). The sand-sized clasts are set in a matrix of a very fine, chertose mosaic that cannot be resolved under the microscope. One of the samples (Os-34) contains crystalline epidote and quartz–feldspar veinlets that cut across clasts and matrix alike. The cutting chips show that the rock is highly indurated, with the chips breaking through rather than around the rhyolite clasts.

These arkosic rocks were probably deposited in low areas in the volcanic terrain during relatively quiet periods of volcanism and are probably interbedded with the volcanic rocks. The occurrence of epidote and quartz–feldspar veinlets indicates that higher than normal temperatures associated with igneous activity did not cease until after deposition.

The rhyolites in the northern tract are significantly different in general composition and petrographic character from those in the central and southern tracts. Briefly, these differences can be summarized as follows:

Northern Tract	Central and Southern Tract
Banding and relict eutaxitic structures common	Directional groundmass texture lacking, felsophyric texture most common
Pyroxene lacking, chlorite not abundant	Pyroxenes and chlorite pseudomorphs common and abundant
Mostly pure rhyolites	Tend toward trachytic–dacitic composition

Feldspar phenocrysts mostly albite–oligoclase with subequal perthite. Locally significant amounts of quartz phenocrysts	Feldspar phenocrysts highly altered, mostly intermediate to calcic oligoclase with lesser perthite. Quartz phenocrysts rare

Table 3 shows the difference in modal composition. Five determinations in the northern tract and four in the central and southern tracts indicate no age difference in the rocks in each tract. The differences in composition are exactly analogous to the variations in the Spavinaw Granite Group. The reason for this difference is not known, although it may be related to differentiation within a large magmatic mass. The relatively low Sr^{87}/Sr^{86} initial ratio and the small error associated with its definition suggests that contamination is not a major factor.

Andesite.—In the eastern part of the northern areas underlain by volcanic rock, seven wells penetrated intermediate volcanic rocks. Two of these in Craig County, Oklahoma (Cg-1, Cg-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 (pl. 2, no. 1).

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 (pl. 2, no. 2), and very sparse plagioclase phenocrysts. In none of these samples was the plagioclase sufficient in quantity or fresh enough to determine the composition. The groundmass is composed dominantly of feldspar colored reddish by hematite dust but also containing abundant small former femic minerals, 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 Co. (Ot-6). For these core holes, it could be argued, on the basis of individual sampled intervals, that the

TABLE 3.—COMPARISON OF AVERAGE MODAL COMPOSITION (IN PERCENT) OF THREE UNITS OF NORTHEAST OKLAHOMA IGNEOUS PROVINCE

	1	2	3a	3b	3c	3d
Groundmass	60.8	59.1*	82.5	70.4	62.0	73.2
Perthite	31.3	12.6	7.5	3.9	15.0	—
Plagioclase	0.4	14.5	3.8	15.5	8.3	10.9
Quartz**	2.1	0.8	2.0	tr	7.6	tr
Chlorite	2.6	5.0	0.7	2.7	1.4	1.9
Biotite	0.5	tr	—	—	—	tr
Amphibole	0.4	0.5	—	tr	tr	0.4
Basaltic hornblende	—	—	—	—	—	1.1
Pyroxene	—	0.1	—	tr	—	1.6
Sphene–leucoxene	0.7	0.5	0.4	0.7	0.5	0.1
Opaque minerals	0.5	1.0	0.3	1.4	0.5	2.5
Sericite–clay–zeolite	tr	3.9	1.6	3.2	3.9	6.1
Epidote	tr	1.3	tr	0.3	0.5	1.4
Other	0.7	0.7	1.2	1.9	0.3	0.8
Number of modes	14	30	33	11	12	5

* Micrographic quartz–feldspar.
** Phenocrysts or discrete quartz only.
1. Osage Microgranite.
2. Spavinaw Granite Group.
3a. Rhyolite of the Washington Volcanic Group, northern tract.
3b. Rhyolite of the Washington Volcanic Group, southern and central tract.
3c. Metarhyolite of the Washington Volcanic Group.
3d. Andesite of the Washington Volcanic Group.

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, indicating that 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, an average of more than 25 percent of the rock volume, while the flow-rock andesites generally carry considerably less than 10 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 that affects rocks of Mississippian age. 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.—Rhyolite bordering the Central Oklahoma Granite Group to the south and west is converted to hornfels. The rhyolite has been gently reconstituted without changing the basic original mineralogy. 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. This area, 130 miles long and about 35 miles wide and underlain by metarhyolite, is too large for anything but regional metamorphism. Contact aureoles rarely exceed more than a few hundred feet in width (Williams and others, 1954, p. 163) and it is virtually impossible to believe that all the metarhyolites are within a few hundred feet of the metamorphic agent; 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 absence of a significant amount of hydrous minerals indicates that no substantial amount of water was added 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 30 percent of the metarhyolites and less than 15 percent of the unmetamorphosed rhyolites. This may be due to secondary growth, although that is considered unlikely because the phenocrysts in the metarhyolites are not larger, simply more numerous. In abundance of phenocrysts the metarhyolites are comparable to tuffaceous rhyolites in the northern tract. The phenocryst-rich metarhyolites are concentrated in Kansas and may owe their appearance to a tuffaceous origin, but evidence for a possible tuffaceous origin 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 (pl. 2, no. 4).

Perthite appears to have been affected by the metamorphism in certain samples, with parts of the perthite cleared of hematite dust and alterations while other parts are apparently unaffected. The cleared parts have the appearance of microcline, although characteristic twinning is lacking. About 16 percent of the rock volume is composed of perthite phenocrysts.

Plagioclase is intermediate albite to sodic oligoclase in composition. About 8 percent of the rock is plagioclase as phenocrysts, with an additional 4 percent of feldspar alterations that are largely derived from plagioclase. The plagioclase is characteristically mottled and clouded with fine indeterminate alterations, hematite dust, epidote granules, and mats of sericite shreds.

Quartz phenocrysts are particularly common, averaging about 8 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 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 is evidenced by a partial rim of included groundmass material around certain phenocrysts. These rims are rarely uniform, occurring around selected phenocrysts, while nearby phenocrysts show no such effects. The included groundmass material may be due to the late magmatic growth of phenocrysts 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 mm in maximum dimension and is uniform in size. The groundmass feldspars are clouded with hematite dust and are indeterminate 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 and is 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.

Spavinaw Granite Group

Introduction

This group is named for the Spavinaw Granite, which crops out in five small hills in Mayes County, Oklahoma. Merritt (1960) described the petrology of the outcropping granite most recently and included a chemical analysis in his report. These five small hills are topographically high knobs on the basement surface that protrude 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 150 miles to southwesternmost Missouri.

Samples from 46 wells in Oklahoma define a generally micrographic granite porphyry comparatively rich in femic minerals. Some samples, considered to be phases of 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 remain essentially constant in all phases.

This group is inferred to underlie approximately 7,300 square miles. The form of the intrusions cannot be determined from the drill holes, but the porphyritic and micrographic character of the rocks gives 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 that will fulfill these requirements is a sill complex, and most of the Spavinaw Granite Group is interpreted as such. It would be carrying this reasoning too far, however, to expect the granite to be a single sill emplaced in a single pulse. In the Wichita Mountains, numerous granites can be mapped as multiple sill injections, with the base of the rhyolite as the probable plane of intrusion. These Wichita Mountain sills are associated with irregularly shaped plutons, and the Spavinaw Granite Group is interpreted as a subsurface analogy. There is, in fact, less textural variation in samples from the Spavinaw Granite Group than in the Wichita Granite Group.

Isotopic Age

The age of the Spavinaw Granite Group is indistinguishable from that of other rock units in the Northeast Oklahoma Province. An isochron age of 1,277 ± 38 million years was determined on eight samples from Oklahoma, Kansas, and Missouri, which is well within error of the 1,285 ± 20-million-year age for the province as a whole. The calculated initial Sr^{87}/Sr^{86} ratio for these determinations is 0.7027 ± .0021, the same, within error, as other units in the area. One U/Pb age from outcrop zircons yielded an age of 1,370 ± 20 million years.

Petrography

The three main constituents—quartz, plagioclase, and perthite—generally make up more than 90 percent of the rock (table 3). All samples available in sufficient quantity for modal analysis contain perthite in considerable excess of free plagioclase, although chemical analyses show normative orthoclase and plagioclase to be very nearly equal. 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 show gradations 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 dense, semiopaque appearance. The alteration makes petrography and modal analysis difficult.

Plagioclase is calcic albite to intermediate oligoclase in composition and most commonly between An_{10} and An_{15}. Generally forming phenocrysts, the plagioclase is found only rarely in the groundmass except where 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, whereas the larger ones are irregular in shape, commonly with a perthite rim.

Plagioclase is extensively mottled by sericite. Clay-zeolites and epidote granules are also present. Femic minerals or their alteration products are not uncommon as inclusions in the larger, irregularly shaped crystals.

Perthite has the shaggy appearance of a mesoperthite. Patch and string-type perthites are not present. The general appearance is that of an exsolved, high-temperature K feldspar. This is supported by the identical appearance of perthite in the granites and in the rhyolites. Certain samples (Rg-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).

Free (non-intergrown) quartz occurs in minor proportions in the femic-rich granites, averaging less than 1 percent of the rock volume. The discrete quartz is essentially unstrained in single crystals.

Primary accessory minerals include magnetite–ilmenite, hornblende, augite, biotite, sphene, apatite, and zircon. Secondary minerals include calcite, dolomite, siderite, feldspar alterations, pyrite, chlorite, tremolitic amphibole, sphene–leucoxene, hematite, epidote, and fluorite. Chlorite, magnetite–ilmenite, feldspar alterations, and epidote are the most abundant and constitute over 10 percent of the rock locally. Apatite needles are rarely absent and are particularly numerous 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 (pl. 4, no. 3). Common hornblende is exceptionally rare but secondary tremolite–actinolite is common. The replacement by chlorite and tremolite–actinolite 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 (Rg-3). Chlorite and tremolite–actinolite may replace a femic mineral as a single large pseudomorph or as a delicate fibrous mat of interlaced crystals.

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

Carbonate minerals replace feldspars in small blebs and are 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 is generally in sparse anhedral crystals or may even be 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 by epidote also contributing to the degradation. The normal appearance of the feldspars, particularly perthite, under the microscope is one of extreme turbidity. Plagioclase is more transparent than perthite, owing rather to less disseminated hematite and mottled alteration than to uniform clouding. These alterations are chiefly a fibrous mat of sericite shreds, but locally fine clay minerals and sparse zeolites have been identified petrographically. In samples near the basement–sediment surface, weathering has leached the reddish color and in some samples has reduced the feldspars to a semiopaque mat of extremely fine alteration material that cannot be resolved under the microscope.

Epidote is a common and relatively abundant secondary mineral that occupies 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., Ce-3-1). Epidote also is associated with chlorite and tremolite–actinolite in the alteration of a former femic mineral.

The texture is porphyritic and micrographic (pl. 4, nos. 1, 2). 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 in the system quartz–albite–orthoclase (Tuttle and Bowen, 1958). The samples containing a very high percentage of quartz-perthite would probably plot very close to the ternary eutectic (none has been chemically analyzed).

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 (Rg-3, Om-5) and a trachytic cutting chip and a dioritic cutting chip in Cherokee County (Ce-1, Ce-3), no other rock types were found in this group. Syenite and quartz–syenite were drilled in the Smith & Daniels 2 Vierhiller (Rg-3) at distinct intervals within a normal granite sequence of about 800 feet in drilled thickness. These are interpreted as younger dikes but may represent a local inhomogeneity in the normal granite. The trachyte in the Pine 1 Lemon (Ce-3) is represented by only a single cutting chip and is possibly analogous to the syenite interpreted as dikes. The diorite found in the M & F 1 Thompson (Ce-1) is more difficult to interpret. In the Spavinaw outcrop, relatively small masses (about 5 mm in length) of dioritic composition occur. Possibly these are smaller xenoliths, either accidental or cognate, that were 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 granites are lower in femic minerals and higher in quartz than the Spavinaw Granite (Ham and others, 1964).

Osage Microgranite

Introduction

The Osage Microgranite was penetrated in 15 wells for which samples were obtained in south-central Osage County, Oklahoma. The microgranites are petrographically the most uniform and unique rock unit in the study area. The mineralogy is variable only in the percentage of major constituents and the occurrence or absence of trace minerals. The rocks are so similar that cuttings from all the wells might have been collected from the same drill hole without undue comment. The one exception is the Sunray Dx S-1 Osage (Os-36), which was drilled near the center of the circular mass.

Isotopic Age

The microgranite covers about 320 square miles, the smallest area occupied by any rock group. Two microgranites have yielded ages of 1,281 ± 48 and 1,224 ± 51 million years. These ages, together with the petrographic kindred of rhyolite and Spavinaw granites, are used to place the rock type in the Northeast Oklahoma Province as part of the hypabyssal–intrusive–extrusive complex.

Petrography

The microgranite is strongly porphyritic, containing abundant phenocrysts of perthite and lesser quartz. The phenocrysts make up 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 contain small masses of finely divided chlorite locally. Some are faintly zoned, possibly because of a change in the ratio of plagioclase to potash feldspar. The rock contains numerous composite phenocrysts with as many as five optic units. The extreme alteration of feldspar phenocrysts that characterizes the Spavinaw Granite Group does not occur in the microgranite. However, the perthite is invariably clouded with evenly distributed hematite dust and tiny vacuoles. Recognizable alteration products are not abundant.

A core from the Texaco 16 W. S. Kohpay (Os-27) contains rounded perthite phenocrysts up to 2.1cm in length that apparently are 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 mm 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 in optical continuity. The average size of these phenocrysts is about 1.5 mm in diameter.

The groundmass is composed chiefly of quartz and perthite. The texture is unusual, and no petrographic term describes the relationship adequately. The quartz in large part is in the form of rods or "spicules" in thin section (pl. 3, nos. 3, 4). These rod forms are probably disc shapes cut transversely. The length-to-width ratio is 5:1 or greater. This highly rodlike 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 the rhyolite is generally much finer, less well defined, and mixed with normal felsophyric texture.

Chlorite occurs in masses of fine, fibrous, unoriented shreds, generally in an intergranular position. Secondary biotite with the same fibrous habit is associated locally with chlorite. In only one sample (Os-36) did any primary femic mineral remain: small relicts of riebeckite were present. Textural position and general outlines suggest that chlorite is a deuteric replacement of magmatic amphibole and biotite.

The samples from the Sunray Dx 1-S Osage are important because this is the well nearest the center of the subcrop area. The texture of rock in these samples is not hypidiomorphic–acicular but merely xenomorphic and fine grained (0.2 mm average). Significantly, this rock contained the only primary femic mineral found in samples from the group. Small relicts of riebeckite are present in a mass of chlorite and secondary biotite. It is not known how characteristic riebeckite is of the original rock, but the pseudomorph outlines suggest that it may have been common, though not abundant.

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 four wells.

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

Magnetite–ilmenite occurs 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, considerable variation that could be mapped locally might be found. In comparison with the 320-square-mile areal extent of the microgranite, the total outcrop of all igneous rocks in the Wichita Mountains is about 400 square miles.

Interpretation

Only a special intrusive process could have caused a distinct rock type to be so uniform petrographically over such a wide area. If this is a single pluton intruded as a roughly circular mass that was 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 up 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 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.

The area was later broadly domed in pre-Late Cambrian time, and the rhyolite cover was removed by erosion. The area shows a history of continued minor instability in late Paleozoic time; this is discussed under structure.

The age relations between the microgranite and the Spavinaw granites are not known, because these rocks are not in contact. Isotopic ages and general petrographic appearance offer 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 Province.

Central Oklahoma Granite Group

Introduction

The Central Oklahoma Granite Group is defined on the basis of evidence from cuttings and cores from 12 wells in 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 the great distances over which these rocks occur in the basement almost certainly require a multiple intrusion by a composite batholith. The petrology of the Central Oklahoma Granite is suggestive of a mesozonal batholithic type of emplacement, in contrast to the epizonal granites of the Northeast Oklahoma Province. Thus, this group is associated with the shallow igneous rocks in time but not in space and represents a distinct environment.

This rock group is considered the youngest in the area because rocks of the Washington Volcanic Group are converted to metarhyolite near the contact with the Central Oklahoma Granites. Although the Spavinaw granites are thought to be younger than the rhyolite, their intrusion is not interpreted as the major metamorphic agent affecting the rhyolite. Epizone granites typically do not cause regional metamorphism, only contact effects, as is 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 Spavinaw granites in Haskell and Le Flore Counties and farther south, outside the study area, in Pontotoc County, Oklahoma. These southern areas are, however, in inferred contact with the Central Oklahoma granites. These mesozone granites were emplaced as the type of intrusion that would provide the heat and volatiles near a given point necessary for regional recrystallization; these are lacking in an epizone intrusion.

Isotopic Age

Thirteen Rb/Sr determinations were made on eight samples from this group. Two of these samples are outside the study area. The resulting isochron yields an age of 1,277 ± 42 million years, almost the exact age given for all rocks in northeast Oklahoma, 1,285 ± 20 million years. The calculated initial Sr^{87}/Sr^{86} ratio for these determinations is 0.7054 ± .0024.

Petrography

The granites of the Central Oklahoma Granite Group characteristically contain both microcline and plagioclase, in contrast to the perthitic character of other Oklahoma rock groups. The rocks vary considerably in their grain size and in percentage of minerals, but the mineralogy is reasonably uniform. The unit is not well defined petrographically, largely because samples were obtained from widely separated sites and because of a relatively coarse grain size, which is not completely suitable for modal analysis, even in core samples.

Microcline is generally clear and unaltered and relatively free of hematite dust. Patch and string-type perthite is common, and 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 small 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 mostly patchy, but relatively uniform sericitization with accompanying hematite dust is also found. Certain zones and the 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 (pl. 3, no. 1). The exception to this undeformed character is two extensively sheared granite gneisses found in the only two wells drilled to basement in the Oklahoma City Field. These rocks contain relict augen of essential minerals separated by highly sheared material (pl. 3, no. 2). The quartz is in fine aggregates reduced from single crystals. The general nature of the shear-reconstitution suggests that the deformation took place under considerable heat and pressure. This would mean that the rocks were not deformed by the faulting that bounds the Oklahoma City Field on the east but were sheared in Precambrian time. Perhaps the Precambrian shearing formed a zone of weakness that was again activated in the late Paleozoic.

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. Granular sphene–leucoxene and, less commonly, abundant epidote are associated along cleavage in the chlorite.

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 minerals, pyrite, and muscovite.

The rocks in this group are generally medium to coarse grained, averaging larger than 5 mm where grain size can be determined. The average mode, determined from two cores and four cutting-chip intervals, shows that microcline accounts for about 50 percent of the total feldspar.

The Central Oklahoma granites are almost certainly equivalent, in part, to the rocks that crop out in the eastern Arbuckle Mountains. The Precambrian rocks in the core of the Tishomingo–Belton Anticline have analogous compositions to those found in wells to the north and yield identical ages. Zircon ages reported by Bickford and Lewis (1979) of 1,370 ± 20 million years for the Tishomingo Granite, 1,399 ± 95 million years for the Troy Granite, and 1,396 ± 40 million years for the Blue River gneiss in the Arbuckle Mountains, demonstrate that the rocks in the Arbuckle Mountains and in northeastern Oklahoma are equivalent in age. The Rb/Sr ages, though lower, are also identical within error (see Denison, 1973).

CHEMICAL COMPOSITION

Eleven chemical analyses have been determined for the basement rocks in northeastern Oklahoma (table 4). The analyses cover all of the petrographic types. Unfortunately, the analyses are not strictly representative of the composition of the rock unit as a whole; e.g., the andesites represent only a small fraction of the total volume of volcanic rocks but account for two of the six analyses of the extrusive rocks. In dealing with subsurface samples, the unavailability of large amounts of sample is a limiting criterion in choosing rocks for analyses. One previous analysis of the outcropping Spavinaw Granite (Merritt, 1960) has been included in these data.

In petrographic examination the volcanic rocks show the most variation, as might be expected (fig. 2). The most silicic samples of rhyolite probably have close counterparts in the Spavinaw granites, but there are no analyses of the purest quartz-perthite rocks.

It is believed that a rigorous treatment and classification of the results of the chemical analyses are unwarranted with the available data. The analyses are presented to show the general chemical character of the rocks encountered in northeastern Oklahoma and to provide a basis for further studies on carefully selected samples.

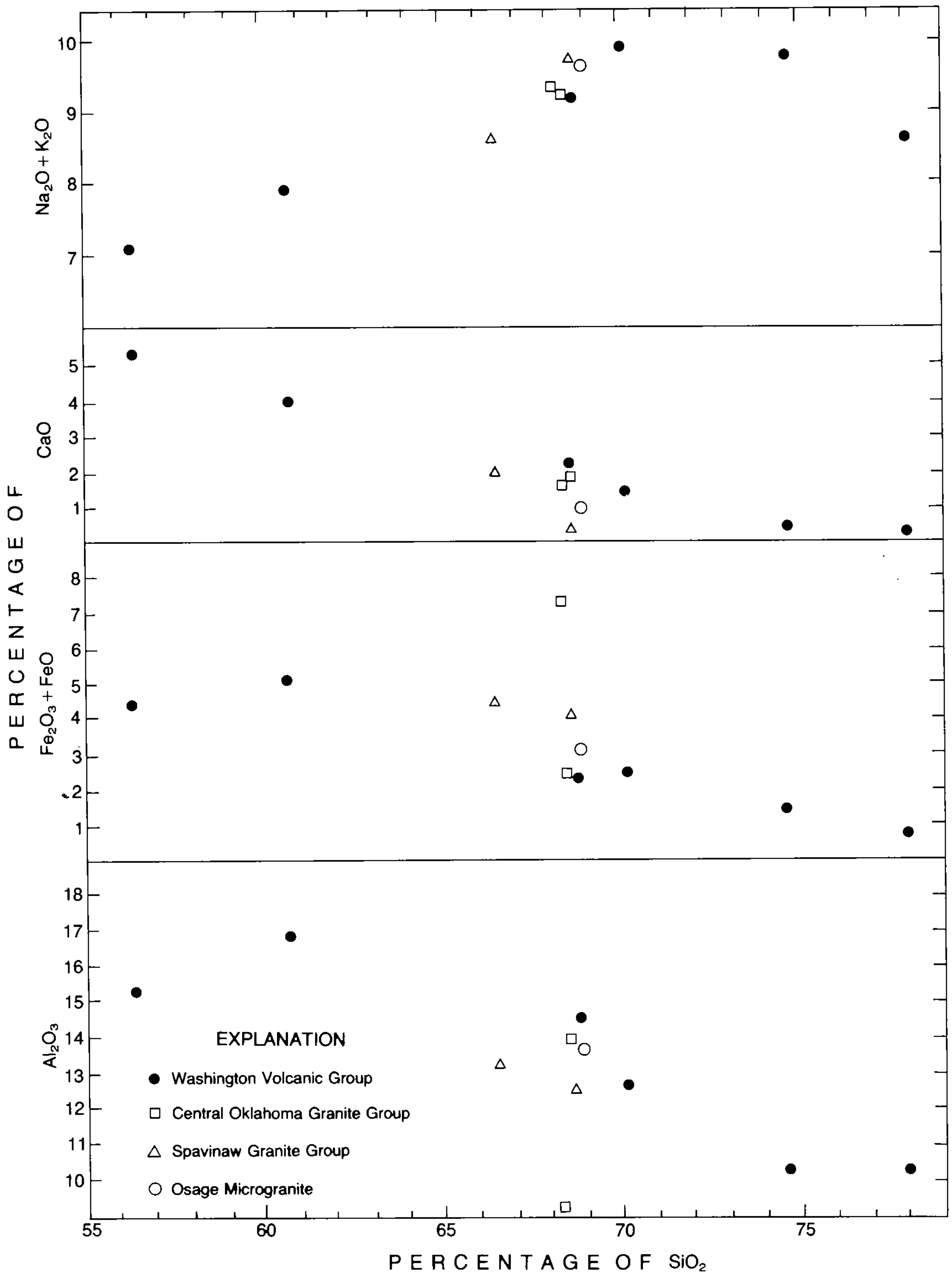

Figure 2. Variation diagram for igneous rocks in northeastern Oklahoma.

TABLE 4.—CHEMICAL ANALYSES, NORMS, AND MODES OF BASEMENT ROCKS IN NORTHEASTERN OKLAHOMA
(Values shown are percentages)

	Rock unit	Washington Volcanic Group						Spavinaw Granite Group		Osage Micro-granite	Central Oklahoma Granite Group	
		A	B	C	D	E	F	G	H	I	J	K
Chemical Analysis	SiO_2	77.98	56.29	60.64	70.04	74.58	68.75	68.59	66.44	68.77	68.49	68.31
	Al_2O_3	11.31	16.39	17.90	13.87	11.38	15.67	13.61	14.27	14.71	14.98	10.32
	TiO_2	.22	.72	.70	.55	.30	.55	.78	.82	.65	.48	.94
	Fe_2O_3	.06	nil	2.80	1.39	.60	.31	2.84	2.21	.59	.68	4.58
	FeO	.72	4.44	2.38	1.09	.81	1.95	1.29	2.27	2.57	1.72	2.63
	MgO	.20	7.13	1.98	.72	.64	.83	1.34	1.64	.49	1.10	.98
	CaO	.18	5.34	3.96	1.42	.39	2.18	.36	1.91	.93	1.79	1.88
	Na_2O	4.77	3.94	4.68	4.74	4.80	4.14	4.71	3.79	4.12	4.54	4.33
	K_2O	3.91	3.18	3.32	5.25	5.06	5.10	5.09	4.85	5.57	4.76	5.02
	H_2O+	.65	2.33	1.06	.80	.91	.52	.24	nil	1.16	1.36	.32
	CO_2	.03	.13	.20	.04	.08	nil	1.07	.77	.41	nil	.74
	Remainder	.01	.02(1)	.33	.09	nil	nil	.01(1)	.53(2)	.01(1)	nil	.03(1)
	Total	100.04	99.91	99.95	100.00	99.55	100.00	99.93	99.50	99.98	99.90	100.08
Norm	Quartz	36.59	—	9.51	19.24	30.52	18.53	19.62	21.65	20.72	18.12	23.02
	Orthoclase	23.10	18.79	19.62	31.02	29.90	30.13	30.07	28.66	32.91	28.12	29.66
	Albite	36.40	33.32	39.58	40.09	30.36	35.02	39.84	32.06	34.85	38.40	25.13
	Anorthite	—	17.65	18.04	1.07	—	9.12	.27	7.61	1.43	6.45	—
	Corundum	—	—	—	—	—	—	.26	—	1.38	—	—
	Acmite	.17	—	—	—	1.74	—	—	—	—	—	10.12
	Na metasilicate	.87	—	—	—	1.92	—	—	—	—	—	—
	Hypersthene	1.16	14.85	5.70	.41	1.53	3.78	3.34	5.00	4.38	3.57	2.92
	Diopside	.59	6.35	.27	4.62	2.18	1.41	—	.41	—	1.98	3.84
	Magnetite	—	—	4.06	2.02	—	.45	1.90	3.20	.86	.99	1.57
	Ilmenite	.42	1.37	1.33	—	.57	1.05	1.48	1.56	1.23	.91	1.78
	Remainder	—	4.95(3)	—	—	—	—	1.53(4)	.61(5)	—	—	
	Normative Anorthite	0	35	32	3	0	21	1	19	4	14	0

		A	B	C	D	E	F	G	H	I	J	K
Mode	Quartz	0.6	tr	tr	—	9.7	0.4	26.5	2.3	1.5	27.8	27.9
	K feldspar	0.5	—	—	6.0	16.8	2.4	39.3	13.9	29.2	27.1	35.7
	Plagioclase	0.8	0.6	13.7	9.6	13.3	15.5	19.9	24.9	—	31.8	19.5
	Groundmass	96.2	88.8	66.6	80.6	59.6	72.7	—	48.1	62.6	—	—
	Biotite	tr	—	—	—	—	1.6	—	—	—	7.5	2.2
	Chlorite	tr	—	2.7	0.6	0.6	0.8	6.4	1.7	4.1	0.6	2.2
	Hornblende	—	4.2	1.3	—	—	—	—	3.1	0.5	—	6.5
	Pyroxene	—	4.8	—	—	—	—	—	—	—	—	—
	Feldspar alteration	1.7	tr	10.2	tr	tr	5.5	5.8	3.0	tr	4.9	3.0
	Opaque minerals	tr	1.5	2.9	0.4	tr	0.3	1.6	1.8	0.2	0.3	1.6
	Sphene–leucoxene	0.2	tr	tr	0.5	tr	0.4	0.4	tr	1.6	tr	1.0
	Other	tr	tr	2.6	2.3	tr	0.4	0.1	1.2	0.3	tr	0.4

(1) P_2O_5.
(2) 0.07% MnO, 0.28% P_2O_5, 0.03% Rb_2O, 0.03% SrO, 0.12% BaO.
(3) 4.91% olivine, 0.04% apatite.
(4) Hematite.
(5) Apatite.

Well list:

A. Phillips Petr. 1-SWD Higgins "A," 23-25N-8E, Osage County (Os-30); cuttings of welded rhyolite tuff 3652–3664 feet. Analyst: John A. Schleicher, OGS, 1962.

B. Eagle Picher P-5 Golden Hawk, 20-29N-23E, Ottawa County (Ot-6); core of andesite porphyry 1781 feet. Analyst: John A. Schleicher, OGS, 1964.

C. Frankfort Oil 1 Van Ausdel, 31-28N-20E, Craig County (Cg-1); cuttings of welded andesite tuff 1715–1890 feet. Analyst: John A. Schleicher, OGS, 1962.

D. Okla. Nat. Gas 1 Stockton, 20-11N-26E, Sequoyah County (Sq-2); core of metarhyolite 6145–6146 feet. Analyst: John A. Schleicher, OGS, 1962.

E. Porter Oil & Gas 20 Miller, 33-23N-3E, Pawnee County (Pw-7); core of metarhyolite 4686–4691 feet. Analyst: John A. Schleicher, OGS, 1962.

F. Tidewater 1 Wood, 7-4N-4E, Pontotoc County (Pc-5); core of metarhyolite 6026 feet. Analyst: John A. Schleicher, OGS, 1964.

G. Emrich & Austin 1 Carter, 5-16N-16E, Wagoner County (Wg-1); cuttings of micrographic granite porphyry 3092–3098 feet. Analyst: John A. Schleicher, OGS, 1962.

H. Spavinaw Granite, 15-22N-21E, Mayes County; outcrop sample of micrographic granite porphyry. Analysts: C. O. Ingamells and D. Thaemlitz, Minnesota Rock Analysis Laboratory, 1959.

I. Norbla Oil 2 Lyman, 24-22N-9E, Osage County (Os-23); core of microgranite porphyry 2972 feet. Analyst: John A. Schleicher, OGS, 1964.

J. Hembree C-3 Hembree, 19-7N-5E, Pottawatomie County (Pt-1); cuttings of granite 7755–7775 feet. Analyst: John A. Schleicher, OGS, 1964.

K. Pan Amer. 1 Tackett, 28-8N-23E, Le Flore County (Lf-1); core of granite 9269 feet. Analyst: John A. Schleicher, OGS, 1964.

The results can be used to make comparisons between rock units that are not possible using petrography alone:

1. The average composition of the granitic rocks shows clearly the overlapping chemical character of the major rock units.
2. The average composition of the granitic rocks is considerably less silicic than comparable suites of rocks in the St. Francois and Wichita Mountains (Kisvarsanyi, 1972; Ham and others, 1964).
3. The Osage Microgranite does not show a more evolved chemical character, even though it is argued, on petrographic and geologic grounds, to be the youngest rock unit.

The nine rocks contain greater than 80 percent normative orthoclase–albite–quartz (the exceptions are the andesites). These fall into the concentration shown in the contoured triangle of Tuttle and Bowen (1958, p. 128) for all plutonic and extrusive rocks of this composition (fig. 3). All the analyses plot in the central part of the diagram marking the ternary eutectic or along the broad thermal saddle between the eutectic and syenite composition (Tuttle and Bowen, 1958, p. 54–56).

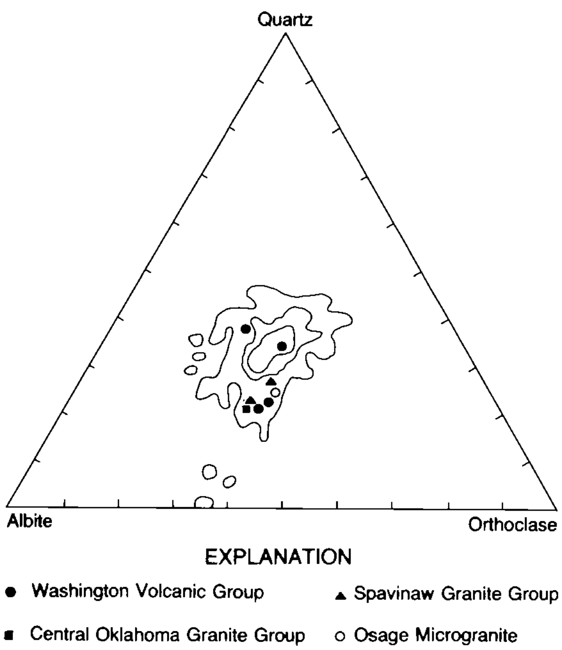

Figure 3. Contoured diagram showing distribution of normative *Ab-Or-Q* in 1,269 analyzed rocks in Washington's (1917) tables that contain 80 percent or more *Ab* + *Or* + *Q* (from Tuttle and Bowen, 1958, p. 128). Readings for rocks from northeastern Oklahoma are superimposed for comparison. Contour percentages are not given.

GRAVITY AND MAGNETIC INVESTIGATIONS

The area is covered by a gravity map (Lyons, 1964), contoured at a 5-milligal interval, and a magnetic map (Jones and Lyons, 1964), contoured at a 100-gamma interval. A bibliography of geophysics in Oklahoma is also available (Roark, 1964).

These maps are useful but are also frustrating when compared to known basement-rock distribution. The disparity demonstrates the impossibility of constructing a basement-rock map solely on the basis of geophysical data. The primary problem in applying gravity information to basement-rock data is that all the major rock units 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 5-milligal interval. 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. It can be determined with certainty that the rock unit coincident with the anomaly, the Osage Microgranite, does not cause the anomaly. Thus, something deeper must cause the anomaly. On the basis of seismic reflections, Roark (1962) suggested that the Osage Island is caused by an "antiroot" or bump on the Moho surface about 10 km in height. This interpretation is supported by the lack of a well-defined magnetic anomaly over the gravity maximum.

Magnetic anomalies shown on the regional map are not well covered by wells to basement. Two of the largest, 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 susceptibilities and density measurements, listed in table 5, offer an idea of the expected range in the samples obtained.

The petrographic difference noted between the northern and central and southern tracts of the Washington Volcanic Group rock is reflected in the magnetic susceptibilities and, to a lesser extent, in average densities. Table 5 shows that the average susceptibility for the northern tract is 109 $\times 10^{-6}$ cgs units, and if the highest value of the 18 determinations is taken out, the susceptibility drops to 63 $\times$ 10^{-6} cgs units.

The rocks from the central and southern tracts have an average susceptibility of 1,093 $\times$ 10^{-6} cgs units. This value is much closer to the 1,265 $\times$ 10^{-6} cgs unit average for the Spavinaw granites.

TABLE 5.—MAGNETIC SUSCEPTIBILITY AND DENSITY DETERMINATIONS OF OKLAHOMA BASEMENT ROCKS

Well	Location	Thin-section number	Magnetic susceptibility $\times 10^{-6}$ cgs units	Density
Washington Volcanic Group, northern tract				
De Mier Oil 3-A Bruner	6-19N-12E	Tu-1-1	54	2.67
De Mier Oil 1-A Country Club	28-20N-12E	Os-22-1 Os-22-2	16 51	2.66 2.65
Keener Oil 29 Osage "A"	8-20N-12E	Os-6-1	2	
Gulf Oil 65 Boston	1-21N-7E	Os-24-1 Os-24-2	106 67	2.70 2.61
Sinclair Oil & Gas 46 Jones	20-21N-8E	Pw-1-1	58	2.61
De Mier 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 Os-41-2	2 46	
Texaco 25-WS Adkinson	32-21N-13E	Tu-4-1	216	
Big Four Petr. 5 Bird	33-22N-7E	Os-16-4	41	2.69
Sunray Oil S-3 Osage	34-22N-10E	Os-1-2	8	
Texas Co. 13 SWD Bennett	12-23N-7E	Os-29-1	72	
Sunray DX S-1 Osage	24-24N-9E	Os-36-1	895*	
Cities Service 1-SWD Osage Lot 292	8-24N-11E	Os-32-1	141	
Phillips Petr. 1-SWD Higgins "A"	23-25N-8E	Os-30-1	8	
Delaware Consol. WS-1 Pilot Flood Tr.	20-27N-15E	Nw-1-3	8	
Average and number of determinations:			109 (18)	2.67 (8)
Washington Volcanic Group, central and southern tracts				
Okla. Nat. Gas 1 Stockton	20-11N-26E	Sq-2-1	84	2.70
USSRAM 1 Marshall	23-13N-19E	Ms-1-1	116	
USSRAM 1 Minor	9-21N-15E	Rg-6-2	247*	
Henderson 1-A Cannon	29-18N-18E	Wg-4-1	1470*	

TABLE 5.—MAGNETIC SUSCEPTIBILITY AND DENSITY DETERMINATIONS OF OKLAHOMA BASEMENT ROCKS—*Continued*

Well	Location	Thin-section number	Magnetic susceptibility $\times 10^{-6}$ cgs units	Density
Henderson 1 Kelly	18-17N-17E	Wg-3-2	1530*	
Amax DAC-2	6-20N-23E	Dr-4-1	735*	2.65*
Amax DAC-4	24-20N-23E	Dr-6-1	2710*	2.68*
Amax DAC-6	19-20N-24E	Dr-7-1	2110*	2.67*
Henderson 1 Carter	26-19N-18E	My-7-2	835*	
Average and number of determinations:			1093 (9)	2.68 (4)
Osage Microgranite				
Norbla Oil 2 Lyman	24-22N-9E	Os-23-1	187	2.69
Pure Oil 191 Osage-Hominy	9-23N-8E	Os-4-2	9	
Texaco 16 W.S. Kohpay	29-25N-8E	Os-27-1	130	2.61
Mid-Continent	31-25N-10E	Os-7-1	33	
Average and number of determinations:			90 (4)	2.65 (2)
Spavinaw Granite Group				
Schermerhorn 1 Tiger	24-16N-12E	Om-5-1	2147	
Gulf 1-5 Berryhill	17-17N-12E	Ck-3-1	753	
M & F Oil 1 Thompson	35-19N-21E	Ce-1-2	375	
Spavinaw Granite outcrop	15-22N-21E	Mayes County	2022 739 487 515	2.70 2.66 2.72
Davis & Miller 1 Knight	34-23N-21E	My-3-1	540	2.61
Southern Union Prod. 1-C Atchison	5-20N-11E	Os-26-1	144	2.65
3-B Oil 1 Helmik	12-26N-21E	Cg-4-5	5340	
Amax SP-2	8-22N-20E	My-8	1490*	2.68*
Amax SP-3	31-22N-21E	My-9	37*	2.62*
Amax SP-4	31-23N-19E	My-10-1	1340*	2.66*

TABLE 5.—MAGNETIC SUSCEPTIBILITY AND DENSITY DETERMINATIONS OF OKLAHOMA BASEMENT ROCKS—*Continued*

Well	Location	Thin-section number	Magnetic susceptibility $\times 10^{-6}$ cgs units	Density
Amax SP-1	13-22N-19E	My-11-1	1650*	2.66*
Little Nick 1 Titus	25-19N-17E	Rg-7-2	49*	
Amax HC-1	27-21N-33W Missouri	Mn-2-1	850*	2.67*
Amax DAC-1	25-20N-23E	Dr-3-1	1790*	2.69*
Amax DAC-3	23-20N-23E	Dr-5-1	2490*	2.68*
Average and number of determinations:			1265 (18)	2.66 (11)
Central Oklahoma Granite Group				
Hembree C-3 Hembree	19-7N-5E	Pt-1-1	1225	
Pan Amer. 1 Tackett	28-8N-23E	Lf-1-1	1929	2.64
Anderson Prichard 28 Welch	17-28N-1E	Ky-1-1	34	
Sinclair Oil & Gas 19 Hartley	18-22N-3W	Gf-1-1	1360	
Magness (Keener) 1 Jones "A"	34-9N-6E	Sm-1-1	177*	
Average and number of determinations:			944 (5)	

*Determined by the author. All other magnetic measurements by J. A. E. Norden. All other density measurements by T. L. Rowland.

In general, the areas underlain by volcanic rocks are characterized by a higher magnetic topography, while those underlain by the Spavinaw granites are lower in relief. This is marked even between the northern-tract volcanic rocks and the Spavinaw, where the average susceptibility contrast of measured samples is more than an order of magnitude in the opposite sense. Clearly, the rocks at the surface are not magnetically representative of the bulk of the northern-tract rhyolites.

However, within the area underlain by 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 exceptionally variable. Fresh rocks yield susceptibilities from 37 $\times 10^{-6}$ cgs units to 5,340 $\times 10^{-6}$ cgs units. This variability in 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 (Cg-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.

The Spavinaw Granite outcrop area was the site of some pioneer work in geophysics. Hawes' (1952) work consisted of a field study of the ground and airborne magnetic fields. In addition, he made laboratory measurements on the susceptibility and remanent and induced magnetic fields of samples collected in the field. His conclusions are beyond the scope of this discussion, but some aspects of his work are germane.

He determined an average density for the granite of 2.655 gms/cm^3 on 97 measurements. In addition, he determined the susceptibility of 41 samples. These varied from 280 to 1,980 $\times$ 10^{-6} cgs units, with an average of 1,210 $\times$ 10^{-6} cgs units. The plot of his results, as well as the determinations made in this study from a much larger area (fig. 4), shows a smooth curve.

The ground magnetics show enormous variations over the outcrops (Hawes' figure 7 is contoured at a 2,500-gamma interval). This exceptionally large variation suggests that susceptibilities have a considerably wider range than is indicated by measurements on small-sized outcrop samples.

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 extent of the influence, and there does not appear to be any explanation from the basement rock for some of the anomalies.

Geophysical data offered only modest aid in constructing the basement-rock map (pl.1) because of overlapping properties and the layered character of some of the rock units. However, the data were used almost exclusively in drawing the contact between the Central Oklahoma granites and the rocks of the Northeast Oklahoma Province. 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.

CONFIGURATION OF BASEMENT SURFACE

The present configuration of the basement surface is a combination of inherited buried topography and later modification by Paleozoic warping, folding, and faulting. There is no area in northeastern Oklahoma where erosion reached and exposed the Precambrian rocks during the late Paleozoic (Jordan, 1962).

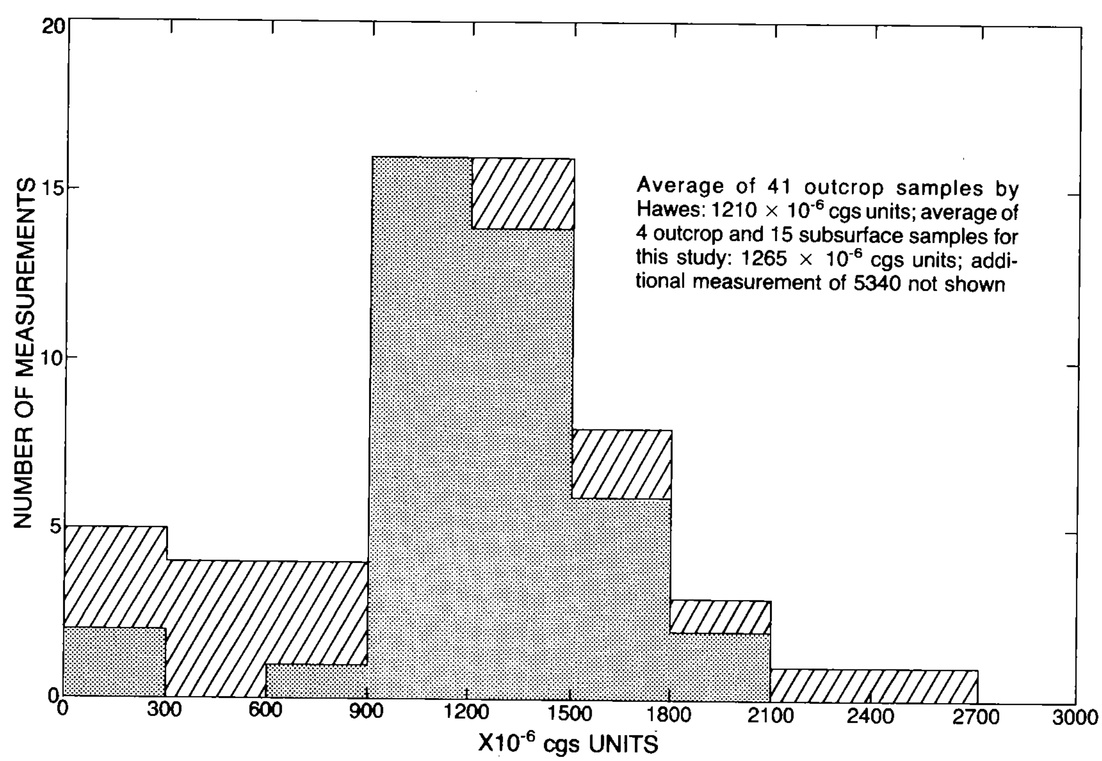

Figure 4. Distribution of 59 measurements of magnetic susceptibility on Spavinaw Granite samples. Patterned measurements from this study (table 5); others from Hawes (1952, fig. 8).

Because of the rugged topography on the basement surface (see also Ireland, 1955; Dille, 1956; Reeder, 1974), 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.

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 Paleozoic features, as is the deep downwarp of the Arkoma Basin. It appears that the ruggedness of topography shown in the published maps of Ireland (1955) and Dille (1956) 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.

The map (pl. 1) is contoured without faulting wherever possible. Huffman (1958, p. 90–97) showed that the maximum displacement on surface faults in the Oklahoma part of the Ozark Uplift is only about 300 feet, which is well under the 500-foot contour interval used in plate 1. The largest single fault bounds the east side of the Oklahoma City Field in Oklahoma County. Here, Gatewood (1970) showed more than 2,500 feet of displacement on the basement surface.

The basic difficulty is simply that the basement surface is not structurally controlled at the scale of contouring used here (500 feet). The basement surface is tilted topography at the scale under consideration. This fact was realized by Ireland (1955). The normal methods of contouring are not particularly successful here because we generally assume a certain symmetry when running contours between data points. This symmetry is not justified in this case, because layered basement rocks—such as rhyolite—form a characteristic asymmetric landscape, e.g., hogbacks, mesas, ridges, and similar features more typical of sedimentary rocks.

The surface was contoured as mature rugged topography. That is to say, no closed basins could be justified unless mirrored in the overlying top of the Arbuckle surface. All available well control was used, including some estimates extrapolated from the depth to Arbuckle Group rocks. Because the thickness of the Arbuckle is controlled locally by basement topography, this is not a particularly reliable estimate. Undoubtedly, it is better than ignoring the data; how much better is debatable.

Two dominant topographic features are apparent in the areas of high relief. The first is a linear ridge parallel to the Spavinaw Arch. This major feature stands as high as 2,000 feet above the surrounding area in eastern Tulsa County. The second feature, in central Osage County, is a series of relatively small rugged hills and mountains. These Ireland (1955) called the Tulsa Mountains. These features have relief differences exceeding 1,000 feet in a single township. Variations of more than 700 feet within a section are recorded in areas of close control. It is not unreasonable to assume that this variation is much more common than can be demonstrated with the available well information. The topographic expression is apparently the reflection of the contact between the Osage County Microgranite and Washington County rhyolites. The hills are on the microgranite near the contact with the rhyolite, and perhaps this is a chilled zone that is more resistant to erosion. Thus, the central Osage Dome is a topographic depression with a breached outer rim of broken hills.

The available evidence suggests the generalization that areas underlain by the Spavinaw Granite are characterized by large features of major relief, whereas those areas underlain by rhyolite and microgranite are characterized by smaller scale, broken features. The Wichita Mountains offer an analogy in that hills supported by rhyolite are smooth, comparatively modest in relief, and individually smaller than those supported by granite.

The thickness maps of Arbuckle and younger sedimentary units of Chenoweth (1968) show the basement surface to be a significant influence on thickness of the overlying sediments and their distribution. The disruption of the Spavinaw Arch in the Tulsa County area is mirrored in the thickness of the Arbuckle, although the coincidence is not precise. The boundary between granite and rhyolite through Tulsa and Rogers Counties is marked by a rapid decrease in the thickness of the Arbuckle Group on the northern (rhyolite) side. The granite–rhyolite boundary on the south through Muskogee and Cherokee Counties is marked by thickening of the Arbuckle Group. In general, the thickness of the Arbuckle and the distribution of sedimentary-rock units covering the basement reflect the general grain of the basement-rock units.

Thus, the present basement-rock surface is the result of tectonic warping and folding and faulting of an inherited topography. The topography reflects the basement-rock types and their particular resistance or susceptibility to erosion.

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 sedimentary rock of Late Cambrian to Ordovician age. Some of these features were later reactivated during the Paleozoic, while others do not appear to have any recognizable influence on the sedimentary rocks.

It is reasonably certain that at one time the rhyolite covered the entire area, or very nearly so. The Spavinaw granites and the Osage Microgranite were intruded under a cover of rhyolite. The metamorphism of the rhyolite near the contact with the Central Oklahoma granites indicates that these mesozonal plutons were intruded, at least partly, into rhyolite at depth. Therefore, where the rhyolite is absent it must be because it has been removed by differential erosion. Areas underlain by rhyolite are relative structural depressions.

The most striking structural feature in northeastern Oklahoma is the broad arch trending northeast across the area (fig. 5). The Spavinaw Granite forms the core of the arch and is flanked by rhyolite. Presumably the rhyolite that once covered the arch has been removed by erosion. The axis of the arch, which is designated the Spavinaw 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 causes are presented in figure 6. The faults in interpretation *A* are parallel to later Paleozoic faults along the Nemaha Uplift and to the Cushing structure in western Creek County. The folds in interpretation *B* are parallel to the Spavinaw Arch. The preservation of rhyolite in the central tract can be used to support the occurrence of folds parallel to the arch. Interpretation *C* is based upon faults parallel to the arch. Interpretation *D* is a simple right-lateral wrench fault. The wrench-fault interpretation is possibly the most intriguing, but it also is the most difficult to support. The late Paleozoic *en-echelon* fault sets (fig. 7), if interpreted as megatension gashes trending generally north through northeastern Oklahoma, suggest a wrench-fault system 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 general geometry of the disruption is mirrored in the thickness of the overlying Arbuckle Group (Chenoweth, 1968).

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 micro-

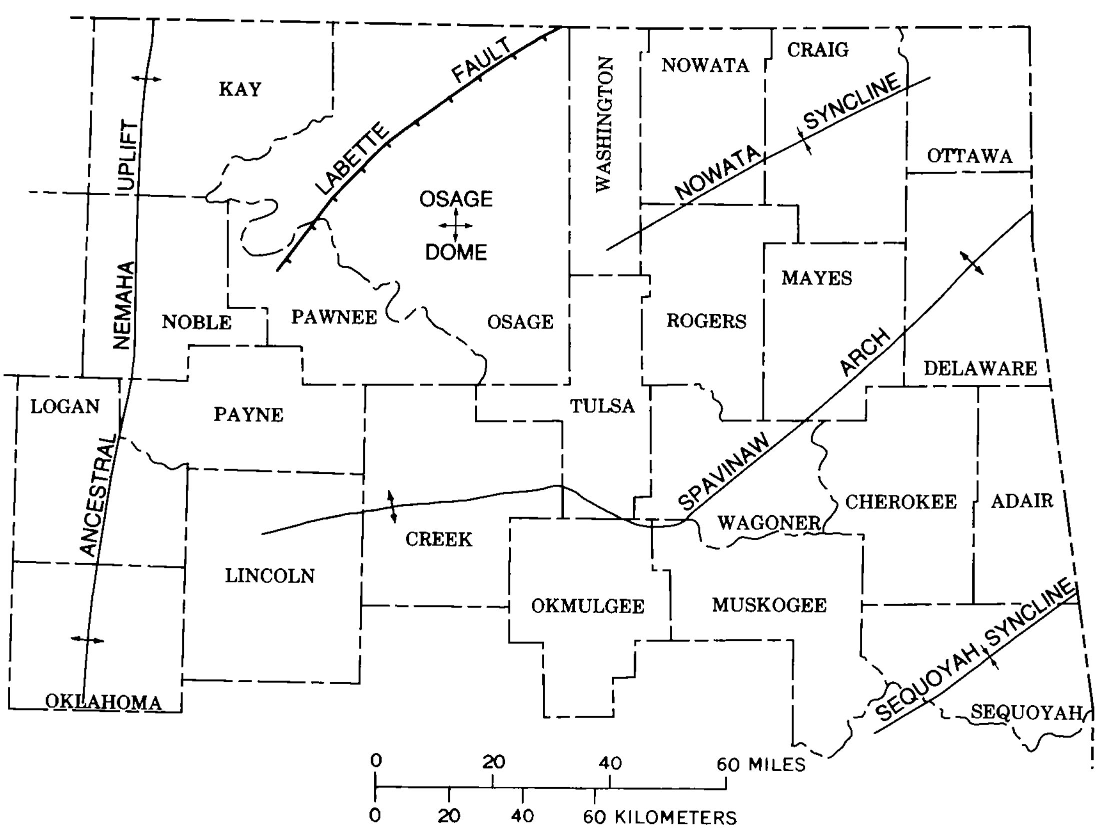

Figure 5. Map showing Precambrian structural features in northeastern Oklahoma.

granite does not cause the anomaly, it possibly reflects instability caused by a deeper source, as is suggested by Roark (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 that separates the rhyolite from metarhyolite and that strikes east-northeast from Pawnee County, Oklahoma, to Cherokee County, Kansas. This fault is here named the

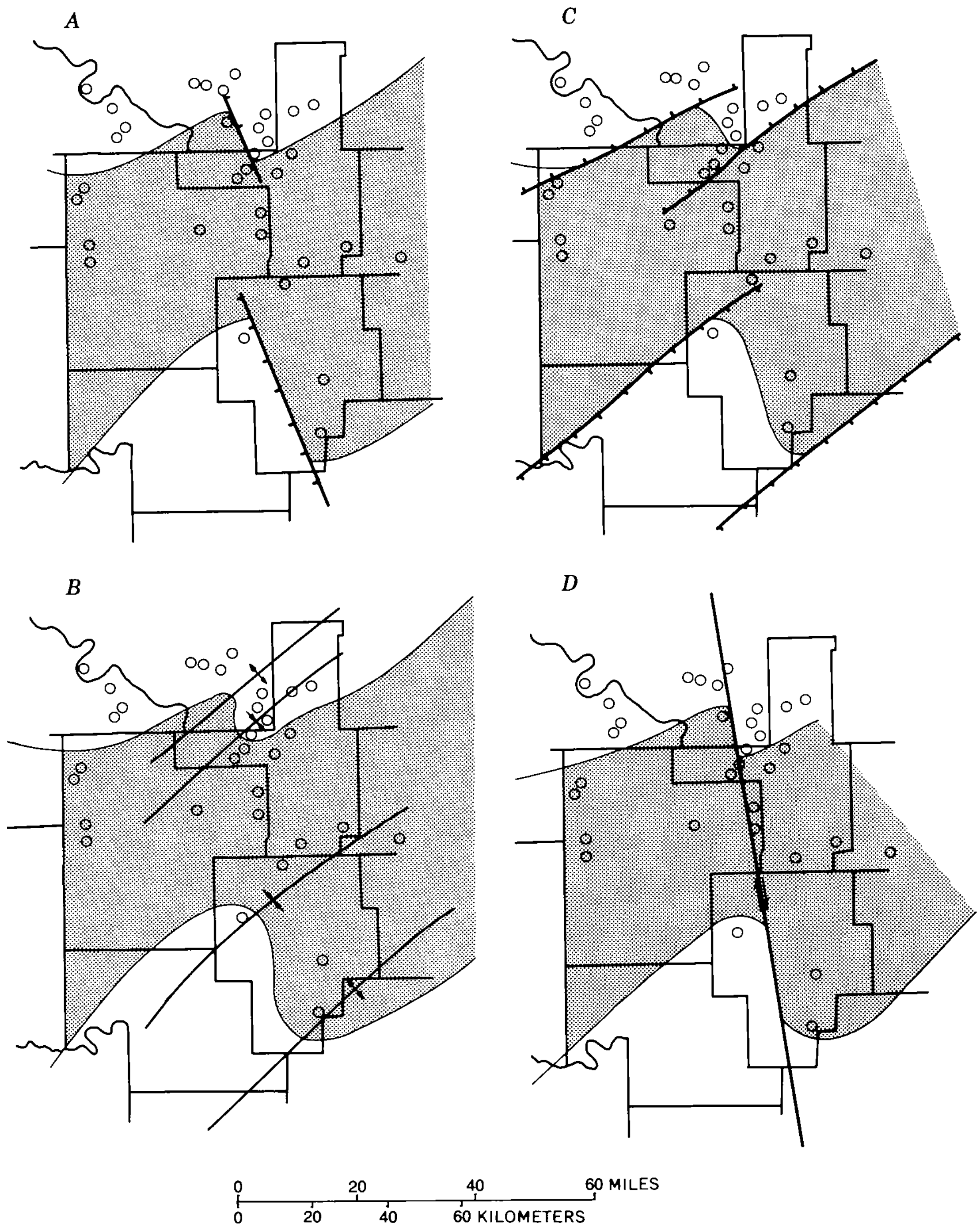

Figure 6. Four possible explanations for disruption of axis of Spavinaw Arch. (See text for discussion.)

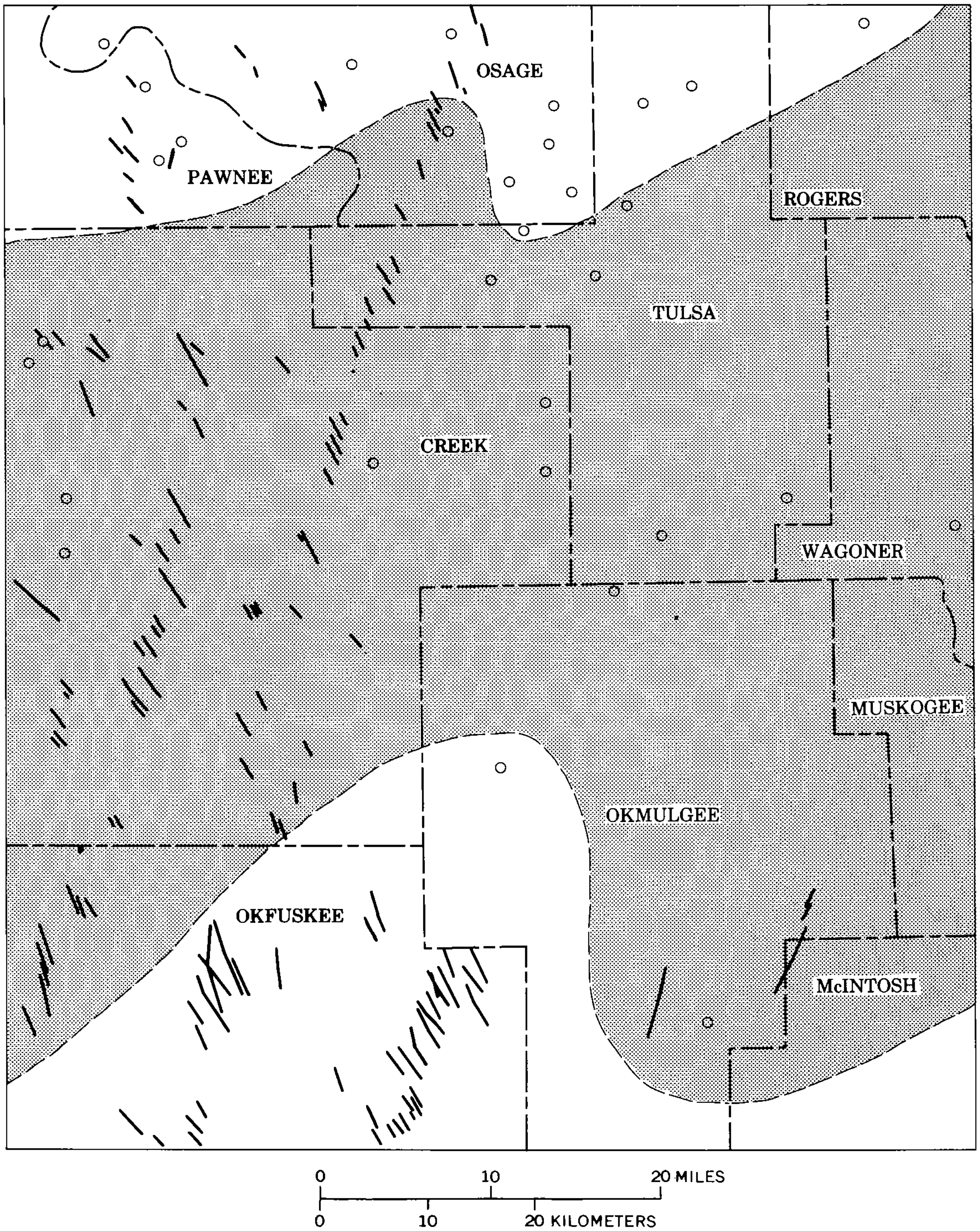

Figure 7. Map showing disruption of Spavinaw Arch in relation to *en-echelon* fault trends in northeastern Oklahoma. Faults taken from *Geologic Map of Oklahoma* (Miser and others, 1954).

Labette Fault for the county in Kansas through which the fault is inferred to strike. The evidence for this fault is: (1) the occurrence of metarhyolites north and west of the fault only, (2) a high-gravity gradient parallel to the fault. There is no evidence that the fault was active in Paleozoic time. The fault is shown in plate 1 and figure 5 as a normal fault, but the dip 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 were preserved in structural lows interpreted as synclines. The northern structure is named the Nowata Syncline for the Oklahoma county through which the structure extends, and the axis of the syncline lies 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 named the Sequoyah Syncline for the Oklahoma county through which the structure extends: The available basement samples in this area are sparser, and the limits of the syncline are poorly defined.

The Nemaha Uplift is a prominent Paleozoic feature that is underlain by coarse-grained granites of the Central Oklahoma Granite Group. This suggests that the Nemaha Uplift was a positive structural area in post-rhyolite and pre-sediment time. Movement on 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. It seems evident, therefore, that Precambrian structure exerted some control on later structure and sedimentation, even though this control of structure by basement rocks is not as close as that found in southern Oklahoma. However, in comparison with the major tectonic features of southern Oklahoma, there is very little structure to control.

SUMMARY

The Precambrian rocks in northeastern Oklahoma are those characteristic of the southern continental interior of the United States. A recent study by R. E. Denison, E. G. Lidiak, M. E. Bickford, and E. B. Kisvarsanyi shows that the southern interior is characterized by epizonal granite–rhyolite complexes and anorogenic mesozonal granite. This study, entitled "Geology and Geochronology of Precambrian Rocks in the Central Interior Region of the United States," will be published by the U.S. Geological Survey in the near future.

The epizonal granite–rhyolite associations were first recognized by Muehlberger and others (1966, 1967). The origin of the complexes remains unclear. Denison and others, in the study mentioned in the preceding paragraph, reached the following conclusions concerning these occurrences:

1. The rocks are preserved in structural depressions; surrounding rocks represent deeper crustal levels of emplacement.
2. The rhyolites are invariably associated with coeval hypersolvus granites that commonly display micrographic quartz–perthite intergrowths.
3. The rhyolites are not associated with any significant volume of other volcanic or sedimentary rocks.
4. The rhyolites are essentially undeformed and are only locally recrystallized.
5. The several tracts of rhyolite–granite are similar, but they are not the same in age; the ages show no simple pattern of variation.

The northeastern Oklahoma rocks differ somewhat from these characteristics. This is the only area in which large areas of contiguous metarhyolite can be demonstrated. Even the small volume of andesite in Oklahoma is unusual and is perhaps unique. The chemical composition of the average northeastern Oklahoma granite–rhyolite is probably less silicic than for other associations (very little chemistry is available for comparison except for a few outcrop areas), although the most silicic northeastern Oklahoma rocks are probably very close to the average.

The mesozonal granites along the Nemaha Uplift are typical of those of the same and other ages throughout the southern interior. Granites containing subequal amounts of perthite, oligoclase, and quartz with a color index less than 10 are exceptionally common.

The Precambrian of northeastern Oklahoma is represented by igneous rocks emplaced or extruded over a narrow time interval. There is very little evidence for the type of rocks that were the host for these younger granitic rocks. To the north in Kansas, the granites are in contact with rocks yielding somewhat older ages (Muehlberger and others, 1966). In Missouri to the northeast, the Northeast Oklahoma Province is in contact with similar but older rocks of the St. Francois Mountains (Bickford and Mose, 1975). There is virtually no Precambrian control to the east and southeast. On the south, rocks equivalent to those in northeastern Oklahoma are in contact with rocks yielding younger ages (Muehlberger and others, 1966). There is no control to the west in the Anadarko Basin, and Cambrian rocks of the Wichita Igneous Province (Ham and others, 1964) are found on the southwest.

There are therefore no definitive data to indicate the relationship of the granite–rhyolite suite in northeastern Oklahoma to surrounding rocks. The suite may have been emplaced and extruded at or near a Precambrian continental margin, but the evidence for or against such a contention is lacking. The rocks of the Northeast Oklahoma Province remain for the present as enigmatic in origin as other granite–rhyolite suites of the southern continental interior.

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APPENDIX

The Appendix includes the following sections: Part I, Basement-Rock Wells, and Part II, Petrographic Descriptions.

Part I—Basement-Rock Wells

Wells are listed in the order of township, range, section, county, operator, and farm. County code numbers shown are used to cite wells on plate 1. No rock data are given, and no code numbers are assigned for wells from which no samples were obtained.

County / Code number	Operator / Farm	Location	Basement depth (ft) / Sea-level depth (ft)	Total depth (ft) / Penetration (ft)	Rock type	Rock group[1]
Pottawatomie Pt-1	Hembree C-3 Hembree	19-7N-5E SE SW SE	7755 −6828	7781 26	Granite	COGG
Haskell Hk-1	Pan. Amer. 1 Williams Unit	36-8N-22E E½ SE NW	9606 −8940	9817 211	Metarhyolite porphyry	WVG
Le Flore Lf-1	Pan. Amer. 1 Tackett	28-8N-23E C SW NE	9248 −8722	9272 24	Hornblende granite	COGG
Seminole Sm-2	Pawnee Petr. 1 Rentie	23-9N-6E W½ NW NE	7224 −6335	7261 37	Granite	COGG
Seminole Sm-1	Magness (Keener) 1 Jones "A"	34-9N-6E NE NE	7283 −6333	7380 97	Granite	COGG
Oklahoma Ok-1	Cities Service 5 Farley	19-11N-2W SW NE NW	8260 −7011	8344 84	Sheared granite and diabase	COGG
Muskogee	Wright & Clee 1 Gay	13-11N-20E NW NW NW	3225 −2622est.	3279 54		
Muskogee	Leonard & Carter 1 Highfill	5-11N-21E NE SE NE	4616 −4136	4706 90		
Sequoyah Sq-2	Okla. Nat. Gas 1 Stockton	20-11N-26E SE SE	6143 −5640	6146 3	Rhyolite porphyry	WVG
Oklahoma Ok-2	Macklanberg-Duncan 1-A Disposal	15-12N-3W NW SW	9832 −8664	9848 16	Granite gneiss	COGG
Okmulgee Om-1	Hamon & Cox 19 E. Reynolds	26-12N-13E SW SE SW	4330 −3702	4358 28	Micrographic microgranite	SGG
Muskogee	Coastal States 1 Hurd-State	34-12N-19E C NE NW	3305 −2751	3320 15		
Sequoyah	Kerr-McGee 1 Sequoyah	21-12N-21E SE SW NE	3102 −2521	3125 23		
Okmulgee Om-2	Mid-Cont. 9 Daniels	12-13N-13E NW NW SW	3540 −2850	3594 54	Micrographic granite porphyry	SGG
Muskogee Ms-1	USSRAM Explor. 1 Marshall	23-13N-19E NW NW SE	3274 −2673	3294 20	Altered rhyolite porphyry	WVG
Sequoyah Sq-1	T. J. Foster 1 Burke-Mabee	15-13N-25E SW SW NE	3190 −1845	3213 23	Rhyolite porphyry	WVG

Okmulgee Om-3	Texas Co. Fee NCT 2 Well 19	11-14N-11E SE SW NW	3847 −3029	3868 21	Rhyolite porphyry	WVG
Muskogee	M. E. Johnson 2 Harris	30-14N-19E SE NW NE	?2024 −?1449est.	2121 97		
Logan	Magness 15-1 Krannig	C N W 15-15N-4W	9742 −8746	9780 38		
Wagoner	Lantz 1 Rulison	4-15N-18E NE NW NW	2970 −2441	4605 1635		
Muskogee Ms-4	W. H. Pine 1 Klein	32-15N-18E NE NW SW	3481 −2846	3496 15	Micrographic microgranite porphyry	SGG
Muskogee	H. F. Campbell 1 Tilley	28-15N-19E SE NE SW	3373 −2823est.	3690 317		
Muskogee	S. E. Cusak 1 Fee	20-15N-20E NE SW SE	1920 −1300est.	1975 55		
Lincoln Ln-1	T. E. Berry 1 Cook	6-16N-6E SE SE SE	5848 −4928	5899 51	Granite	SGG
Creek Ck-6	Sellers Petr. 2 Tarr	3-16N-7E SE NE NW	4450 −3418	4505 55	Micrographic granite porphyry	SGG
Okmulgee Om-5	Schermerhorn 1 Tiger	24-16N-12E NE SE SE	2628 −1950	2640 12	Micrographic microgranite porphyry	SGG
Tulsa Tu3	Kewanee Oil 16 Stewart	4-16N-13E C S½ NE NW	2396 −1732	2398 2	Micrographic microgranite porphyry	SGG
Okmulgee Om-4	Wood Oil 1 Miller	32-16N-14E NE SE NW	4110est. −3300est.	3915	(Not basement)	
Wagoner Wg-1	Emrich & Austin 1 Carter	5-16N-16E SW NE NW	3092 −2519	3098 6	Micrographic granite porphyry	SGG
Cherokee Ce-3	W. H. Pine 1 Lemon	33-16N-21E C SW SE	2083 −1393	2093 10	Micrographic granite porphyry	SGG
Creek Ck-2	Cosden Oil 17 Barnett	22-17N-7E NE NW SE	3660 −2649	3704 44	Micrographic granite porphyry	SGG
Creek	Sinclair Prairie 4 Washington	32-17N-8E SE SW SW	3766 −2868	3777 11		
Creek	Prairie Oil & Gas 3 Letts	23-17N-9E SE SW SE	4325 −3493	4344 19		

[1]Abbreviations: *COGG*, Central Oklahoma Granite Group; *OM*, Osage Microgranite; *SGG*, Spavinaw Granite Group; *WVG*, Washington Volcanic Group.

County Code number	Operator Farm	Location	Basement depth (ft) Sea-level depth (ft)	Total depth (ft) Penetration (ft)	Rock type	Rock group[1]
Creek Ck-4	Central Commercial 3 Hay	10-17N-10E SW NW SW	4200 −3417	4282 82	Micrographic granite porphyry	SGG
Tulsa	Curt Brown 9 Winston	2-17N-12E NE SW SE	3593 −2910	3594 1		
Creek Ck-3	Gulf Oil 1-5 Berryhill	17-17N-12E SE NW NE	3918 −3198	3932 14	Pyroxene micrographic granite porphyry	SGG
Tulsa Tu-2	Wilcox Oil & Gas 1 Hulputta	27-17N-14E NW NW NW NW	3360 −2754	3400 40	Micrographic granite porphyry	SGG
Wagoner Wg-3	Henderson 1 Kelly	18-17N-17E SW SW SW	1804 −1251	2505 701	Pyroxene rhyolite porphyry	WVG
Wagoner	J. H. Scriba 3 Cane	30-17N-18E NW NW SW	1610 −1607est.	1740 130		
Cherokee Ch-4	Amax T-1	15-17N-22E NW SE SW corner	1414 −494	1476 62	Rhyolite porphyry	WVG
Payne Py-1	Deep Rock Oil 3 Little Chief	4-18N-5E NE NW NE	3593 −2775	3600 7	Micrographic granite porphyry	SGG
Payne	Berry 17 Cockran	30-18N-5E S½ NE SE SE	4038 −3144	4057 19		
Creek	Cortez Oil 4 Gilbra	2-18N-7E NW SW NW	3995? −3185	3995		
Creek Ck-7	Sand Springs Home 13 Atkins	4-18N-7E NE SW NW	3640 −2815	3811 171	Micrographic microgranite porphyry	SGG(?)
Creek Ck-8	Riverside (Owens) 2 Yarhola	8-18N-7E NW SW SE	3793 −3045	3810 17	Micrographic microgranite porphyry	SGG(?)
Creek	Nabob Oil 1 Fixico	17-18N-7E SW SW NE	3485 −2703	3515 30		
Creek Ck-1	Gulf Oil G-26-S N. Glenn Unit	29-18N-12E SE NW SE	3898 −3158	3904 6	Micrographic granite porphyry	SGG
Wagoner Wg-2	Little Nick 2 Weldon	6-18N-18E NE SE SE	— —	2216 —	Rhyolite porphyry	WVG
Wagoner Wg-4	Henderson 1-A Cannon	29-18N-18E NE NW SW	1093 −367	1680 587	Pyroxene rhyolite porphyry	WVG

Payne Py-2	Magnolia Petr. 10 Main	34-19N-4E SW NW NW	4146 −3206	4151 5	Micrographic granite porphyry	SGG
Payne	Philco 11 Morgan	10-19N-5E W½ NE NE SW	4460 −3589	4506 46		
Payne Py-3	Wood Oil 1 Curley Chief	33-19N-5E SW SW SE	3757 −2939	3792 35	Micrographic granite porphyry	SGG
Creek	Magnolia Petr. 4 Richards	32-19N-7E NW SE SW	3887 −3040	3960 73		
Creek	Wood Oil 9 Bartlett	18-19N-9E C NE¼	3665 −2860	3736 71		
Tulsa	Texas Co. 2 Scott	10-19N-10E SW NW SE	2599 −1924	2606 7		
Tulsa	Sweeney 1 Husky	22-19N-11E C SW SE	2867 −2083	3071 204		
Tulsa Tu-9	Dotson et al. 1-B Jefferson	23-19N-11E SE SE NE	3010 −2191	3015 5	Pyroxene micrographic granite porphyry	SGG
Tulsa	Cleary Petr. 1-A Knoch	34-19N-11E W½ NE NE NE	2882 −2056	2897 15		
Tulsa Tu-1	F. De Mier 3-A Bruner	6-19N-12E SW SW SE	2700 −2018	2726 26	Altered welded rhyolite tuff and rhyolite porphyry	WVG
Tulsa	Lamberton 1 SWD Fee	15-19N-12E SE SE NE SW	3360 −2721	3364 4		
Tulsa Tu-5	Texas Co. Tulsa Refinery	23-19N-12E C SE NW	3435 −2800est.	3460 25	Micrographic granite porphyry	SGG
Wagoner	Winter 1 Bilby	1-19N-15E NW SE SW	2700 −2120est.	2704 4		
Rogers	Big Bear 1 Courtney	21-19N-17E SE NE NE	2385 −1775	2398 13		
Rogers Rg-7	Little Nick 1 Titus	25-19N-17E SW NE NE	2030 −1410	2119 89	Granite	SGG
Rogers Rg-1	Reed & Son 1-A Koenig	27-19N-17E SE SE NW SE	2397 −1772est.	2415 18	Granite	SGG
Mayes My-7	Henderson 1 Carter	26-19N-18E SW NE SW	1950 −1335	2005 55	Rhyolite porphyry	WVG

[1]Abbreviations: *COGG*, Central Oklahoma Granite Group; *OM*, Osage Microgranite; *SGG*, Spavinaw Granite Group; *WVG*, Washington Volcanic Group.

County Code number	Operator Farm	Location	Basement depth (ft) Sea-level depth (ft)	Total depth (ft) Penetration (ft)	Rock type	Rock group[1]
Mayes	National Assoc. Petr. 1 Balloue	9-19N-20E NW SE SW	1135 −465	1142 7		
Cherokee	Cherokee Oil & Gas 1 Brixey	36-19N-21E SW NE NW	2513 −1713est.	2857 344		
Cherokee Ce-1	M & F Oil 1 Thompson	35-19N-21E C SE NE	1800 −1000est.	1935 135	Micrographic granite porphyry	SGG
Cherokee Ce-2	R. Begeman 1 Begeman Ranch	20-19N-23E NW SE NW	1399 −292	1426 27	Micrographic microgranite porphyry	SGG
Cherokee	Gahoma Oil & Gas 1 Crittenden	35-19N-23E NE NE SW	1190 −453	1831 641		
Adair	Adair Oil & Gas 1 Brown	32-19N-25E NE SE NW	1395 −270est.	1430 35		
Noble Nb-1	Shell Oil 1 Magney	17-20N-2W C/SW SW	7062 −5793	7084 22	Granite	COGG
Garfield	Shenandoah 2 Miesner	10-20N-4W NE SW NE NW	7792 −6736	7823 31		
Pawnee	Pawnee 1 Gripe	7-20N-6E SE NE SE	3950 −2986	3964 14		
Pawnee Pw-3	Tidal-Osage 8 Arnold	3-20N-8E NE SE SW	3206 −2305	3217 11	Rhyolite porphyry	WVG
Pawnee Pw-4	Minnehoma 1 Richards	9-20N-8E NE NW NW	3046 −2027	3072 26	Welded rhyolite tuff	WVG
Pawnee	Flight-Beacon 1 Yowell	9-20N-8E NW NW NE	3130 −2102	3262 132		
Osage Os-26	Southern Union Prod. 1-C Atchison	5-20N-11E SE SE NW	3233 −2454	3245 12	Micrographic granite	SGG
Osage Os-35	Texaco 1 Osage C	24-20N-11E C NE SW	3635 −2631	3690 55	Rhyolite porphyry	WVG
Osage	Sunray Oil S-1 SW 4-20-12	4-20N-12E NE NE SW	2883 −2117	2893 10		
Osage	Sunray Oil S-2 SW 4-20-12	4-20N-12E SW NE SW	2807 −1945	2868 61		

Osage Os-6	Keener Oil 29 Osage "A"	8-20N-12E NE NE NE	2158 −1236	2161 3	Welded rhyolite tuff	WVG
Osage	Gillespie & Sons 21 Osage	8-20N-12E NE NE NE	2140 −1240est.	2145 5		
Osage	Gillespie & Sons 22 Osage	8-20N-12E C E½ NE NE	2212 −1312est.	2220 8		
Osage	Gillespie & Sons 24 Osage	8-20N-12E NW NE NE	2198 −1298est.	2198		
Osage	Keener Oil 1-A Osage "A"	8-20N-12E NW SE NE	2784 −1846	2802 18		
Osage	Sunray DX Oil 36 Osage	9-20N-12E N½ NW NW	2332 −1449	2344 12		
Osage	Barnsdall Oil 23 Osage	9-20N-12E C W½ W½ NW	2425 −1469	2435 10		
Osage	Winona Oil 27 Osage	9-20N-12E C W½ E½ NE	2730 −2004	2770 40		
Osage Os-22	De Mier Oil 1-A Country Club	28-20N-12E C SE NW	2632 −1894	2654 22	Banded rhyolite porphyry	WVG
Osage	Fred De Mier et al. 2-A East	28-20N-12E NW NW NE	2786 −2032	2810 24		
Tulsa Tu-6	Dowell 1 Fee	31-20N-13E SW SE NW	3296 −2569	3310 14	Micrographic granite porphyry	SGG
Rogers	Irwin 1 Cox	23-20N-14E NE NE SW	3190 −2412	3360 170		
Rogers	1 McAlester	24-20N-17E NE NE SE	1067? −427est.	1128 61		
Rogers	Layne & Fransworth 1 Fleming	35-20N-17E SW SE NW	495 +177	527 32		
Mayes My-2	Dixon 1 Drew	8-20N-19E SW NE NW	1302 −632est.	2395 1093	Granite?	SGG
Delaware Dr-2	M & F Oil 1 Ransom	18-20N-22E SW NW SW	2184 −1165	2215 31	Micrographic granite porphyry	SGG
Delaware Dr-4	Amax DAC-2	6-20N-23E SE SE NE	1674 −509	1723 49	Rhyolite porphyry	WVG

[1]Abbreviations: *COGG*, Central Oklahoma Granite Group; *OM*, Osage Microgranite; *SGG*, Spavinaw Granite Group; *WVG*, Washington Volcanic Group.

County Code number	Operator Farm	Location	Basement depth (ft) Sea-level depth (ft)	Total depth (ft) Penetration (ft)	Rock type	Rock group[1]
Delaware Dr-5	Amax DAC-3	23-20N-23E NE NE NW	876 −302	948 72	Microgranite porphyry	SGG
Delaware Dr-6	Amax DAC-4	24-20N-23E SW NE NE	1639 −418	1654 15	Rhyolite porphyry	WVG
Delaware Dr-3	Amax DAC-1	25-20N-23E C SW NE	1290 −92	1333 43	Microgranite porphyry	SGG
Delaware Dr-7	Amax DAC-6	19-20N-24E SE SE SW	1414 −140	1451 37	Rhyolite porphyry	WVG
Osage Os-24	Gulf Oil 65 Boston	1-21N-7E SE SW NE	2963 −2181	3000 37	Rhyolite porphyry	WVG
Osage	Potter (Viking) 1-D Osage	1-21N-7E SW NW SE	3142 −2359	3164 22		
Osage	King Res. (Viking) 1-A Osage Boston	1-21N-7E W½ SE NE NE	3124 −2396	3131 7		
Osage	Viking E-4 Osage	1-21N-7E NE NE SW NE	2975 −2229	3050 75		
Pawnee Pw-1	Sinclair Oil & Gas 46 Jones	20-21N-8E C SE SW	2929 −1968	2945 16	Rhyolite porphyry	WVG
Osage	Lewis Oil 1 Osage	3-21N-9E SW SW SW	2757 −1842	2845 88		
Osage	Moore Oil & Ohio Oil 10 Osage	9-21N-9E SE NW SW	2571 −1651est.	2571		
Osage Os-13	Gled Oil 2 Osage	9-21N-9E C SW	2576 −1600	2667 91	Rhyolite porphyry	WVG
Osage Os-14	Moore Oil & Ohio Oil 24 Osage	9-21N-9E N½ SW SW	2536 −1626	2646 110	Microgranite porphyry	OM
Osage	White 2-A Osage	9-21N-9E SW SW SW	2607 −1664	2615 8		
Osage	Wachtman 4-A Osage	9-21N-9E SW NE NW SW	2610 −1710	2675 65		
Osage Os-34	Sunray DX 8 Osage	17-21N-10E NE SW NE	3351 −2482	3390 39	Rhyolite arkose	WVG

Osage Os-17	F. De Mier 1-A Zink	5-21N-11E N½ SW NW	2924 −2030	2995 71	Altered rhyolite porphyry	WVG
Osage	Veitch 7-A Atkins	22-21N-11E SE SE NW	3651 −2806	3652 1		
Osage Os-41	Sunray DX 21-NW-32-21-12	32-21N-12E NW NE NW	2554 −1906	2578 24	Welded rhyolite tuff	WVG
Tulsa Tu-7	Superior Oil 1 Blakemore	26-21N-13E SW NW SW	1363 −709	1462 99	Rhyolite porphyry	WVG
Osage	Finance Oil & Gas 34 Osage	19-21N-9E SE SW SE	3200 −2316	3202 2		
Osage	Sunray Oil S-2 Osage	30-21N-12E NW NW SE NE	?2900 −?2219	2906 6		
Osage	Grimes-Gillespie 5 Osage	30-21N-12E NW NW SW	2060 −1340	2061 1		
Osage	Sunray DX Oil 21-NW 32-21-12	32-21N-12E NW NE NW	2573? −1925	2578 5		
Osage	Hamon & Cox S-14 Osage	32-21N-12E C N½ NE NE	?2965 −2284	2965		
Tulsa	Texaco 35-WS Panther	17-21N-13E SE SW NW NW	3060 −2438	3071 11		
Tulsa Tu-8	Superior Oil 2 Blakemore	26-21N-13E NE SW SE	1566 −906	1586 20	Rhyolite porphyry	WVG
Tulsa Tu-4	Texaco 25-WS Adkinson	32-21N-13E C N½ NE	2742 −2120est.	2812 70	Rhyolite tuff flow	WVG
Rogers	Shannon & Carroll 1 Duncan	10-21N-14E SE NW SW	1902 −1206	1923 21		
Rogers Rg-6	USSRAM Explor. 1 Minor	9-21N-15E SE NW NW	2157 −1291	2180 23	Rhyolite porphyry	WVG
Rogers Rg-3	Smith & Daniels 2 Vierhiller	36-21N-16E SE SE NE	2246 −1596est.	3109 863	Micrographic microgranite and granite porphyry with syenitic dikes	SGG
Noble Nb-2	Stanolind 1 Shoop	27-22N-2W NW SW SE	6445 −5405	6446 1	(None observed)	
Garfield Gf-1	Sinclair Oil & Gas 19 Hartley	18-22N-3W SW SW NW	5461 −4346	5954 493	Granite	COGG

[1]Abbreviations: *COGG*, Central Oklahoma Granite Group; *OM*, Osage Microgranite; *SGG*, Spavinaw Granite Group; *WVG*, Washington Volcanic Group.

County Code number	Operator Farm	Location	Basement depth (ft) Sea-level depth (ft)	Total depth (ft) Penetration (ft)	Rock type	Rock group[1]
Osage Os-16	Big Four Petr. 5 Bird	13-22N-7E SE NW SW	3760 −3003	3835 75	Altered rhyolite porphyry	WVG
Osage	Jernigan & Morgan 1 Osage	10-22N-8E NE SE SW	2850 −1916	3851 1		
Osage Os-20	Red Bank Oil 2 Little	14-22N-8E SW SE NW	3422 −2561	3429 7	Microgranite porphyry	OM
Osage	Moore 14 Henderson	35-22N-8E N½ NE NE SW	3605 −2589	3627 22		
Osage Os-23	Norbla Oil 2 Lyman	24-22N-9E NW SE SW	2933 −2066	2972 39	Microgranite porphyry	OM
Osage	Alkay 2-A Osage	6-22N-10E SW SW SW	2642 −1788	2657 15		
Osage	Tesoro 20-1 Osage	20-22N-10E SE NW NW NW	2236 −1453	2257 21		
Osage	Producers 14 Osage	20-22N-10E SW NW NW NW	2178 −1396	2221 43		
Osage	Tidal-Osage 19 Wildhorse	32-22N-10E SE SW NE	2387 −1530	2434 47		
Osage	Tidal-Osage 18 Wildhorse	32-22N-10E C E½ NE	2217 −1373	2222 5		
Osage	Tidal-Osage 20 Wildhorse	32-22N-10E SW-SE-NE	2267 −1413	2290 23		
Osage	Crown Central 31-A Osage	32-22N-10E NE NW SE NE	2215 −1390	2280 65		
Osage	Crown Central 31-B Osage	32-22N-10E NE SW SW NE	2802 −1984	2814 12		
Osage	Gilcrease Oil W-SW 2 Osage	33-22N-10E NE NE NW NE	3093 −2243	3097 4		
Osage Os-15	Tidal-Osage 26 Wildhorse	33-22N-10E C W½ NW	2622 −1793	2670 48	Rhyolite porphyry	WVG
Osage	Sunray Oil S-1	34-22N-10E NW NE SW	2909 −2038	2911 22		

Osage	Sunray Oil S-2	34-22N-10E SW SE NW	2703 −1797	2725 22		
Osage Os-1	Sunray Oil S-3 Osage	34-22N-10E S½ S½ SW	3210 −2370	3235 25	Rhyolite porphyry	WVG
Osage Os-2	Okmar Oil S-1 Boren	34-22N-10E SE SE NW	3485 −2621	3485	Rhyolite porphyry	WVG
Osage Os-25	Bay Oil 1 Osage (White)	9-22N-11E SW NE SW	2129 −1203	2131 2	Rhyolite porphyry	WVG
Osage	Dolly 1 Osage	9-22N-11E NW NW SE	2730 −1824	2780 50		
Osage	ECC 1-WS Osage	18-22N-11E SW NE NE SW	2660 −1824	2705 45		
Rogers	W. N. Allison 1 Vanderpool	12-22N-14E SE SE NE	2640 −1940	2643 3		
Tulsa	L. B. Allen 1 Atwood	21-22N-14E SW SW SW	1593 −988	1595 2		
Rogers Rg-2	Lucien Conner 2 Nichols "A"	25-22N-14E NW SE SE	2514 −1853	2636 122	Rhyolite porphyry	WVG
Rogers	Carter & Smith (Evans) 2-A Penner Bros.	4-22N-15E SE NW SE SW	2677 −2047	2722 45		
Rogers	E. N. Brockman 1 Nichols	31-22N-15E NW NW NE	1815 −1003	1828 13		
Rogers	Duquesne Oil & Gas 1 Doublehead	31-22N-15E NE NE SE	1785 −1001	2765 980		
Mayes	Northeastern Oil 1 Dickerson	12-22N-18E SE SE NW	1767 −1075	1847 80		
Mayes	Wm. Netzebrand	13-22N-19E SE	202 +423	262 60		
Mayes My-11	Amax SP-1	13-22N-19E NW NW NW	1745 −1050	1809 64	Micrographic granite porphyry	SGG
Mayes My-8	Amax SP-2	8-22N-20E NW NE NW	1792 −1125	1837 45	Micrographic granite porphyry	SGG
Mayes	(Outcrop of Spavinaw Granite)	15-22N-21E NW	+650est.			
Mayes My-9	Amax SP-3	31-22N-21E SW corner	1413 −466	1439 26	Micrographic granite porphyry	SGG

[1]Abbreviations: *COGG*, Central Oklahoma Granite Group; *OM*, Osage Microgranite; *SGG*, Spavinaw Granite Group; *WVG*, Washington Volcanic Group.

County / Code number	Operator / Farm	Location	Basement depth (ft) / Sea-level depth (ft)	Total depth (ft) / Penetration (ft)	Rock type	Rock group[1]
Noble Nb-3	Okla. Nat. Gas 1 Hardrow	15-23N-2W NW SE	5464 −4496	5508 44	Granite	COGG
Garfield Gf-2	Cameron (Hoke) 3 Ford	31-23N-3W SE SE SW	6595 −5458	6612 17	Granite	COGG
Pawnee Pw-2	Watchorn Oil & Gas 11 Miller	33-23N-3E NW NE SE	4570 −3604	4582 12	Metarhyolite porphyry	WVG
Pawnee Pw-7	Porter Oil & Gas 20 Miller	33-23N-3E SW SE SW	4678 −3673	4697 19	Metarhyolite porphyry	WVG
Osage Os-29	Texas Co. 13 SWD Bennett	12-23N-7E SW SE NW	3468 −2464	3542 64	Rhyolite porphyry	WVG
Osage Os-9	Pure Oil 192 Osage-Hominy	8-23N-8E SE NW SE	2572 −1612	2575 3	Microgranite porphyry	OM
Osage Os-5	Pure Oil 190 Osage-Hominy	8-23N-8E SW NE SE	2536 −1590	2595 59	Microgranite porphyry	OM
Osage Os-37	Pure Oil 201 Osage-Hominy	8-23N-8E SE SE SE	3155 −2223	3165 10	Microgranite porphyry	OM
Osage Os-38	Pure & Sinclair 196 Osage-Hominy	8-23N-8E SW NE SW	3000 −1924	3006 6	Microgranite porphyry	OM
Osage	Sinclair-Prairie-Pure 16 Osage	9-23N-8E NE SW SW	2611 −1640	2615 4		
Osage Os-4	Pure Oil 191 Osage-Hominy	9-23N-8E SW SW	2602 −1614	2612 10	Microgranite porphyry	OM
Osage	Sinclair-Prairie-Pure 171 Osage	9-23N-8E NW SE SW	2646 −1676	2677 31		
Osage Os-43	Producers 2 Osage (Pettit)	20-23N-8E NE SW SE	2618? −1676	2727 109	Microgranite porphyry	OM
Osage	Sinclair-Prairie 12 Osage	25-23N-8E SW NE SE	2545 −1688	3037 492		
Osage Os-28	J. G. Buell 14 Osage	25-23N-8E NE SW SE	2383 −1523	2390 7	Microgranite porphyry	OM
Osage	J. R. Higgins 16 Osage	25-23N-8E NW NE SW SE	2475 −1632	2480 5		

Osage	F. De Mier 1-A (Money Tree)	29-23N-8E NW NE NW	2913 −1859	2922 9		
Osage	Cox & Hamon 42 Osage (Manion U.)	19-23N-9E NW SW SE	2914 −2109	2921 7		
Osage	J. M. Boyd 2-A Osage (Airport)	30-23N-9E SW SW NW SW	?2549 −?1723	2551 2		
Osage	Shamrock Oil C-4 Stuart Trust	1-23N-10E NW SE SW	2796 −1967	2800 4		
Osage	Hamon & Cox S-7 Sundown	25-23N-10E NE SE NW	2904 −2081	2912 8		
Osage	Texas Co. 9 Bigheart	36-23N-10E C N½ S½ NW	2181 −1270	2186 5		
Osage Os-18	Amerada Petr. 1 Hardy	7-23N-11E NW NW SE	2349 −1405	2384 35	Microgranite porphyry	OM
Osage Os-11	Cities Service 1-5 S. Barnsdall U.	8-23N-11E NW SE NE	3007 −2242	3032 25	Rhyolitic arkose	WVG
Osage	C & E 1-A Osage	16-23N-11E NE SW SE	2737 −1826	2742 5		
Osage	Hamon & Cox S-51 Osage	5-23N-12E NW NW SW SW	2935 −2229	2955 20		
Mayes My-1	J. L. Milligan 1 Lee	17-23N-19E SE SE SE	1897 −1197	1957 60	Micrographic granite porphyry	SGG
Mayes My-10	Amax SP-4	31-23N-19E SE corner	1850 −1183	1890 40	Micrographic granite porphyry	SGG
Mayes My-6	J. Bander 1 Brixie (Brixey)	15-23N-20E SW SW SE	1649 −979est.	1685 36	Micrographic granite porphyry	SGG
Mayes My-3	Davis & Miller 1 Knight	34-23N-21E NE SW NE	1600 −944	1622 22	Micrographic granite porphyry	SGG
Delaware Dr-1	Commercial Oil 1 Gardner	17-23N-25E NW NW NW	1019 +26	1023 4	Micrographic granite porphyry	SGG
Osage	Texas Co. 1-WS, Others Tr.1	16-24N-7E SW NE NW	4291 −3238	4300 9		
Osage	Texas Co. 17 WS, Farrell Tr. 17	21-24N-7E NW NE	4216 −3217	4251 35		

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County Code number	Operator Farm	Location	Basement depth (ft) Sea-level depth (ft)	Total depth (ft) Penetration (ft)	Rock type	Rock group[1]
Osage Os-10	Texas Co. 1-5 Smith Tr. "A" 26	28-24N-7E NW NE SE	3757 −2677	3772 15	Rhyolite porphyry	WVG
Osage	F. M. Pinney 36, Tr. 291	15-24N-8E SW SW NW	2504 −1490	2560 56		
Osage	F. M. Pinney 36, Tr. 291	15-24N-8E NW SW NW	2505 −1488	2563 58		
Osage	Marland & Gled 3 Kohpay	16-24N-8E C of NL SE NE NE	2708 −1707	2720 12		
Osage Os-19	Marland & Gled 2 Kohpay	16-24N-8E SE SE NE	2480 −1451	2585 105	Microgranite porphyry	OM
Osage Os-36	Sunray DX S-1 Osage	24-24N-9E NE SW NW	3276 −2296	3325 49	Microgranite porphyry	OM
Osage	Sunray DX 21 Wynona	25-24N-9E SW SE NW SE	3049 −2129	3050 1		
Osage	Barnsdall Oil 17 Osage	12-24N-10E SW NW NW	2890 −2095	2961 71		
Osage Os-32	Cities Service 1-SWD Osage Lot 292	8-24N-11E NW SE SW	2804 −2031	2821 17	Banded rhyolite porphyry	WVG
Osage	Petrolite 6-D Osage	18-24N-11E SW SE NE SE	3080 −2348	3104 24		
Osage Os-8	Ohio Oil S-1 Osage B-82	25-24N-11E NW NE NW	2854 −1936	2864 10	Rhyolite porphyry	WVG
Osage	Dyco 3 Osage	29-24N-11E C SE SW	1780 −910	1812 32		
Osage	Homaokla 8 Keeler	30-24N-11E NE SE SE	1761 −933	1864 129		
Osage	Hamon & Cox S-55 Osage	31-24N-11E E½ W½ SW	2296 −1385	2352 56		
Washington Ws-3	Reinhardt & Donovan 1 Abel	27-24N-13E C SW SE	3000 −2390est.	3002 2	Rhyolite porphyry	WVG

Rogers	Liebmann Prod. 1 J. Corlett	12-24N-15E NE SW SE	2635 −1945est.	2685 50		
Craig	E. A. North 1 Harris	15-24N-19E NW NE NW	1930 −1180est.	1957 27		
Craig Cg-5	Dye-Henry 1 Ross	20-24N-21E NW SW NE	1755 −899	1764 9	Granite	SGG
Kay	Anderson Prichard 1 Endicott	34-25N-1W N½ NE SE	5494 −4522	5495 1		
Kay Ky-2	Continental Oil Brett "A"	8-25N-2E SW NE SE	5310 −4310	5349 39	Granite	COGG
Kay	Continental Oil 1 Brett	8-25N-2E SW NE SE	5314 −4316	5348 34		
Osage	Sullivan & Leroux 1 Hadden	3-25N-4E N½ SW SW SE	5196 −4061	5232 36		
Osage	Oliphant 2 Cox	21-25N-4E NW NE NE NE	5240 −4138	5241 1		
Grant	Earlsboro 1 Mulkey	7-25N-4W SW NE NE	7428 −6402	7497 69		
Osage	Atlantic Ref. 4-V569	19-25N-8E NE SW NE SW	2847 −1753	2897 50		
Osage Os-40	Atlantic Ref. 9-V569	19-25N-8E NW NE SW	2830 −1741	2838 8	Rhyolite porphyry	WVG
Osage Os-30	Phillips Petr. 1-SWD Higgins "A"	23-25N-8E SW SW SW	3628 −2730	3663 35	Welded rhyolite tuff	WVG
Osage	Arbtex Oil & DeMier 8 Blackbird	27-25N-8E SE SE SW SW	3022 −1918	3050 28		
Osage Os-27	Texaco 16 W. S. Kohpay	29-25N-8E NE NE NE	2813 −1723	2849 36	Microgranite porphyry	OM
Osage	Burton Oil 93 Osage	10-25N-9E SW NE SE NE	2995 −2209	3003 8		
Osage	Osage Prod. Co. 1 Osage	19-25N-9E SE SW SW	3647 −2755	3651 4		
Osage Os-7	Mid-Continent 1 Osage Tr. 201	31-25N-10E NE SW SW	2525 −1625est.	2565 40	Microgranite porphyry	OM

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County Code number	Operator Farm	Location	Basement depth (ft) Sea-level depth (ft)	Total depth (ft) Penetration (ft)	Rock type	Rock group[1]
Osage Os-12	Ohio Oil 87 Osage Unit "C"	20-25N-11E SW NW SW	3013 −2063	3034 21	Rhyolite porphyry	WVG
Osage	Hamon & Cox S-2	23-25N-11E NW¼	3202 −2271	3209 7		
Osage Os-42	Gulf Oil 3 Price Unit 1-5	30-25N-11E 680′WL 925′SL (NE¼)	3180 −2308	3195 15	Rhyolite porphyry	WVG
Washington Ws-4	Empire Gas & Fuel 3 McElmore	25-25N-12E NE SW NE	2340 −1585	2368 28	Rhyolite porphyry (tuff?)	WVG
Washington	J. C. Bixler 1 Sears	10-25N-13E NE NE SE	2333 −1664	2400 67		
Craig	J. C. Starr 1 Hill	19-25N-20E NE NE NE SE	1827 −1155	2318 491		
Craig	J. C. Starr 1 Cass	32-25N-21E NW NW NW	1688 −973	1695 7		
Delaware	J. C. Starr 1 Starr	28-25N-24E NW SW NW	1135 −355est.	1138 3		
Osage	Carter Oil 1 Johnson	9-26N-6E NW NW NW	4234 −3222	4241 7		
Osage Os-21	Kewanee Oil WS-1 Botts	14-26N-6E NW SW SW	4472 −3252	4478 6	Metarhyolite (tuff?)	WVG
Osage	A. A. Cameron 10 Bowen	18-26N-6E SE SW SE	4309 −3285	4310 1		
Osage	I.T.I.O. 447 Osage	16-26N-12E SE NE NE	1705 −992	1770 65		
Washington	Link Oil 1 Whiteturkey	17-26N-13E NE NE SW	1775 −1041	1805 30		
Washington Ws-7	Greene and Jones S-1 Hildebrand	20-26N-13E NW NW	1987 −1217est.	2367 380	Welded rhyolite tuff	WVG
Craig Cg-3	Frankfort Oil 1 Bluejacket	4-26N-19E NW NW NW	2102 −1267	2129 27	Rhyolite porphyry	WVG

Craig Cg-4	3-B Oil 1 Helmik	12-26N-21E NW NW	1769 −1019est.	1946 177	Micrographic granite porphyry	SGG
Grant	Deer Creek 1 Booth	23-27N-3W NW NW	5496 −4430	6172 676		
Kay	Bradford & Mayo 1 Horinek	2-27N-3E NE SE NW	4634 −3383	4640 6		
Osage Os-3	Phillips Petr. 17 Mott	11-27N-5E NE NE SE	4568 −3416	4610 42	Metarhyolite porphyry	WVG
Osage	Gypsy Oil 8 Bryant	18-27N-8E NE SE SE	3430 −2361	3444 14		
Osage Os-39	Appleton 1 Hickory Creek	22-27N-8E S½ N½ SW	3630 −2572	3798 168	Rhyolite porphyry	WVG
Osage	I.T.I.O. 445 Osage	31-27N-12E SW SW NW	1910 −1034	1925 15		
Washington Ws-2	Taylor 6-B Garrett	3-27N-13E C NE SW	2270 −1523	2289 19	Welded rhyolite tuff	WVG
Washington Ws-8	Bonaventure S-1 Chamberlain	8-27N-14E SE SE NW	2276 −1478	2298 22	Rhyolite porphyry	WVG
Nowata	Frankfort Dist. 1 Allsup	1-27N-15E NW NW SE	2445 −1674	2514 69		
Nowata Nw-1	Delaware Consol. WS-1 Pilot Flood Tr.	20-27N-15E NW NW NE	2480 −1730est.	2509 29	Rhyolite porphyry	WVG
Nowata	Prairie Oil & Gas 105 Security	27-27N-16E SW SE SW	1955 −1205est.	2070 115		
Kay Ky-1	Anderson Prichard 28 Welch	17-28N-1E NW NE SW	4405 −3259	4407.5 2.5	Granite	COGG
Kay Ky-3	Marland Refg. et al. 1 Joynson	18-28N-3E C NE SE	4780 −3613	4827 47	Metarhyolite porphyry	WVG
Washington	Keener Oil A-1 Sheets	11-28N-13E NW NW NE	2880 −2042	2920 40		
Washington Ws-5	Barnsdall (Roxanna) 7 Rigdon	30-28N-13E C SW	2548 −1858est.	2565 17	Welded rhyolite tuff	WVG
Nowata	Ramsey Petr. 1 Ludowici	16-28N-16E NE SW SW	1583 −834	1587 4		

[1]Abbreviations: *COGG*, Central Oklahoma Granite Group; *OM*, Osage Microgranite; *SGG*, Spavinaw Granite Group; *WVG*, Washington Volcanic Group.

County Code number	Operator Farm	Location	Basement depth (ft) Sea-level depth (ft)	Total depth (ft) Penetration (ft)	Rock type	Rock group[1]
Craig Cg-2	Wackerle Oil 4 Hood	19-28N-20E SE SW SE	1493 −655	1590 97	Welded andesite tuff	WVG
Craig Cg-1	Frankfort Oil 1 Van Ausdel	31-28N-20E SE NE NW	1692 −833	2014 322	Welded andesite tuff	WVG
Craig	City of Welch	29-28N-21E SW NW SW	1483 −633	1566 83		
Ottawa Ot-4	Amer. Zinc Demo 2 (A2-2)	8-28N-22E NW NE SE	291 ± 3 +479 ±	305 14	Micrographic granite porphyry	SGG
Ottawa Ot-5	Amer. Zinc Demo 7 (A2-7)	8-28N-22E NW NE SE	345 +430 ± 3	355 10	Micrographic granite porphyry	SGG
Ottawa Ot-1	City of Miami 3 Goodrich Rubber	24-28N-22E SE NE SW	1045 −247	1055 10	Micrographic granite porphyry	SGG
Kay	Clyde Becker 7 Schooland	16-29N-3E NW NE SW	4950 −3765	5009 74		
Washington Ws-6	Empire Gas & Fuel 1 Thompson	22-29N-13E NW SE SE	2700 −1925	3175 475	Rhyolite tuff	WVG
Craig	J. A. Ervin Petr. 1 Maxon	14-29N-18E NE SW NE	2054 −1149est.	2143 89		
Craig	Empire Gas & Fuel 1 Siegel	34-29N-19E C W½ NW	2035 −1110est.	2045 10		
Ottawa Ot-3	Commerce Mining & Royal. 1 Bird Dog Mine	13-29N-22E SW SE SE	1185 −363	1206 21	Micrographic granite porphyry	SGG
Ottawa Ot-2	Commerce Mining & Royal. 159 Beaver	19-29N-23E SW SW SE	1762 −929	1773 11	Micrographic granite porphyry	SGG
Ottawa Ot-7	Eagle Picher 43-C A. Beaver	19-29N-23E NE NW NE	1610 −777	1657 47	Microgranite porphyry	SGG
Ottawa Ot-6	Eagle Picher P-5 Golden Hawk	20-29N-23E SW SW SE	1730 −898	1797 67	Andesite porphyry	SGG

[1]Abbreviations: *COGG*, Central Oklahoma Granite Group; *OM*, Osage Microgranite; *SGG*, Spavinaw Granite Group; *WVG*, Washington Volcanic Group.

Part II—Petrographic Descriptions

The descriptions of the samples from wells are arranged alphabetically by county. The wells are arranged within the county by the code number (e.g., Os-1, Os-2, etc.), keyed to plate 1. The thin sections examined from the wells are listed below the well name. The thin section and depth directly above the description were chosen as representative of the type of rock found in the well. More than one interval is described from wells that contain more than one rock type and from wells that penetrated a substantial depth into the basement. In the first paragraph of the descriptions, the numerals following the mineral and rock constituents indicate the approximate percentages present.

M & F Oil 1 Thompson, 35-19N-21E, Cherokee County

Ce-1-1, cuttings, 1800–1870 feet
Ce-1-2, cuttings, 1870–1920 feet
Ce-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 contains extensive epidote in veins and crystalline masses. One cutting chip is dioritic in composition, containing plagioclase, abundant chlorite, and 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 orientations of optic 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 closely.

Begeman 1 Begeman Ranch, 20-19N-23E, Cherokee County

Ce-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 found in feldspars. The former femic mineral is completely altered to chlorite. Apatite in fine needles is abundant. Small amounts of carbonate have replaced along veinlets and small irregular blebs, and are concentrated near chlorite. Grain size: phenocrysts 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 1 Lemon, 33-16N-21E, Cherokee County

Ce-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.

Amax T-1, NW SE SW 15-17N-22E, Cherokee County

Ce-4-1, core, 1432 feet

RHYOLITE PORPHYRY: Groundmass, 63.7; plagioclase, 17.9; perthite, 9.5; feldspar alterations, 5.0; chlorite, 4.1; leucoxene, 0.7; iron ore, 0.1; apatite, tr.; zircon, tr.; quartz, tr.; calcite, tr.

Phenocrysts of plagioclase, perthite, and small rare quartz are set in a finely felsophyric groundmass of quartz–feldspar. Chlorite replaces a former femic mineral and is associated with apatite, zircon, and leucoxene. Titaniferous iron oxides are now fine leucoxene and hematite, although some small magnetite crystals are present. Plagioclase is albite and contains very abundant local sericitic mats. Perthite is found as discrete crystals and as partial and total rims around plagioclase cores. Perthite is turbid with hematite dust and vacuoles. Veins of quartz and calcite are present. Grain size: phenocrysts to 3 mm; groundmass, 0.05 average. Texture: porphyritic–felsophyric.

The well cored rhyolite of the Washington Volcanic Group.

Frankfort Oil 1 Van Ausdel, 31-28N-20E, Craig County

Cg-1-1, cuttings, 1692–1715 feet
Cg-1-3, cuttings, 1815–1890 feet
Cg-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 pyroxene or basaltic hornblende. 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 part of the Washington Volcanic Group.

Wackerle Oil 4 Hood, 19-28N-20E, Craig County

Cg-2-1, cuttings, 1493–1517 feet
Cg-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 is 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 veinlike mass. Grain size: phenocrysts, to 1.5 mm; groundmass, average microcrystalline. Texture: porphyritic–eutaxitic.

Only 2 miles north of the other welded andesite tuff (Crg-1), this rock is an example of the Washington Volcanic Group.

Frankfort Oil 1 Bluejacket, 4-26N-19E, Craig County

Cg-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 blurred 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 Volcanic Group.

3-B Oil 1 Helmik, 12-26N-21E, Craig County

Cg-4-2, cuttings, 1790–1800 feet
Cg-4-4, cuttings, 1920–1930 feet
Cg-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 pseudomorphs replaces 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 1 Ross, 20-24N-21E, Craig County

Cg-5-1, cuttings, 1715–1764 feet

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

The rock is rather coarse, and the cutting chips are comparatively small. Perthite and quartz compose 99% of the cutting chips. Small amounts of fibrous chlorite, sphene–leucoxene, and opaque minerals are present. 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 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 replaces common augite and what appears to have been an amphibole. The groundmass is delicately spherulitic and micrographic. Phenocrysts appear to be plagioclase and perthite; all are highly sericitized in mats of shreds.

Perthites are wormy due to differential alteration. Apatite is in particularly large and numerous crystals. 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 similar to outcrop examples of the Spavinaw Granite Group some 64 miles to the northeast.

Cosden Oil 17 Barnett, 22-17N-7E, Creek County

Ck-2-1, cuttings, 3664–3668 feet
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 is intergrown with quartz. Plagioclase is comparatively rare and is 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 Oil 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 delicately micrographic–spherulitic groundmass contains highly altered perthite and plagioclase phenocrysts. Chlorite is particularly abundant as pseudomorphs. Several crystals of 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 3 Hay, 10-17N-10E, Creek County

Ck-4-3, cuttings, 4250–4282 feet
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 is present as well as quartz in an intergrowth of quartz–feldspar. Plagioclase found as non-intergrown crystals. Perthite occurs both in intergrowth and discrete. The boundaries between phenocrysts and intergrowth are poorly defined. Sericite flakes are well crystallized but associated with secondary minerals. Grain size: phenocrysts to 4.5+ mm; groundmass, 2.7 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 1212 ± 48 m.y.

Sellers Petr. 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 extensively replace 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 on the western margin of the large negative magnetic anomaly in Creek County.

Sand Springs Home 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 Microgranite. Tentatively, this rock is placed in the Spavinaw Granite Group on the basis of geographic location.

Riverside (Owens) 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 2 miles to the northeast, this well contains a granite closely related to the Osage Microgranite on the basis of petrography. The granite is tentatively placed in the Spavinaw Granite Group, with some reservations.

Commercial Oil 1 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 is sparse, as are all other accessory minerals. Phenocrysts have altered cores. Some parts of groundmass approach hypidiomorphic texture. 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 & F Oil 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 some 12 miles south of the outcrop.

Amax DAC-1, C SW NE 25-20N-23E, Delaware County

Dr-3-1, core, 1329 feet

MICROGRANITE PORPHYRY: Micrographic quartz–feldspar, 63.5; plagioclase, 16.6; feldspar alterations, 8.2; chlorite, 3.0; perthite, 2.7; tremolite–actinolite, 2.0; epidote, 1.5; iron ore, 1.4; sphene, 0.5; apatite, 0.2; calcite, 0.2; zircon, tr.

The texture and grain size are variable, but feldspar phenocrysts are set in a generally finely micrographic groundmass of quartz–feldspar. Groundmass coarsenings are considerably richer in quartz; the rock as a whole contains less than a normal amount. Chlorite pseudomorphs are in part associated with similarly shaped tremolite–actinolite. Epidote and minor sphene are also associated with chlorite. Apatite is common in large, well-formed prisms. Sericite-clay is common as a replacement of plagioclase. The plagioclase is in the andesine–calcic oligoclase range. Perthite is in discrete small phenocrysts and as thin rims around plagioclase. Grain size: phenocrysts, 4 mm; groundmass 0.3 mm average. Texture: porphyritic–micrographic–hypidiomorphic.

The well cored a microgranite of the Spavinaw Granite Group that is very close to the contact with the rhyolites.

Amax DAC-2, SE SE NE 6-20N-23E, Delaware County

Dr-4-1, core, 1704 feet

RHYOLITE PORPHYRY: Groundmass, 60.8; plagioclase, 26.3; calcite, 5.9; perthite, 4.1; leucoxene, 1.1; feldspar alterations, 0.5; apatite, 0.4; chlorite, 0.4; iron ore, 0.4; epidote, 0.1; zircon, tr.

The rock is very quartz-poor, possibly approaching a trachyte in composition. The groundmass is mostly feldspar with abundant chlorite as fine shreds with dirty violet interference colors. The chlorite is in linear "trails" that surround subrounded groundmass areas. Plagioclase is calcic oligoclase, contains minor sericite but is turbid with hematite dust and vacuoles. Perthite is in small discrete crystals and as partial rims around plagioclase. Calcite is common in large masses associated with leucoxene and chlorite. Apatite is common. Grain size: phenocrysts, 4+ mm; groundmass, 0.05 mm average. Texture: porphyritic–felsophyric.

The rhyolite is part of the Washington Volcanic Group and is similar to other rhyolites drilled in the area. The feldspar yielded an Rb/Sr age of 1270 ± 32 m.y.

Amax DAC-3, NE NE NW 23-20N-23E, Delaware County

Dr-5-1, core, 947 feet

MICROGRAPHIC PORPHYRY: Micrographic quartz–feldspar, 63.4; plagioclase, 15.3; feldspar alterations, 10.4; chlorite, 2.9; perthite, 1.8; calcite, 1.7; iron ore, 1.7; tremolite–actinolite, 1.4; epidote, 0.6; sphene–leucoxene, 0.6; apatite, 0.2; zircon, tr.

Phenocrysts of altered oligoclase–andesine and minor but fresh perthite are set in a fine groundmass of partly micrographic, partly hypidiomorphic quartz–feldspar. Chlorite pseudomorphs—many with an actinolite rim—are associated with epidote, sphene–leucoxene, and calcite. Tremolite–actinolite is also found in discrete crystals. Apatite is common. Magnetite is in rounded, partly embayed crystals. The plagioclase is mottled with sericitic mats but is partly water clear. Grain size: phenocrysts to 7 mm; groundmass, 0.5 mm average. Texture: porphyritic–micrographic–hypidiomorphic.

The microgranite of the Spavinaw Granite Group is close to the contact with the volcanic rocks. The feldspar yielded an Rb/Sr age of 1303 ± 24 m.y.

Amax DAC-4, SW NE NE 24-20N-23E, Delaware County

Dr-6-1, core, 1652 feet

PYROXENE RHYOLITE PORPHYRY: Groundmass, 66.8; plagioclase, 13.1; feldspar alterations, 7.4; perthite, 3.9; iron ore, 2.7; chlorite, 2.6; tremolite–actinolite, 1.2; pyroxene, 1.0; sphene–leucoxene, 0.6; apatite, 0.4; epidote, 0.3; zircon, tr.

Phenocrysts of perthite, plagioclase, iron oxides, and pyroxene are set in a groundmass composed mostly of quartz–feldspar. Most of the pyroxene phenocrysts have been replaced by chlorite rimmed by actinolite. Granular sphene is common in these chlorite pseudomorphs. The plagioclase is extensively mottled with sericite. Perthite contains abundant hematite dust and vacuoles but is generally fresh. Apatite is unusually abundant. Grain size: phenocrysts to 5 mm; groundmass, 0.08 average. Texture: porphyritic–felsophyric.

The rhyolite is part of the Washington Volcanic

Group. The occurrence of pyroxene as phenocrysts is restricted to the rhyolites south of the Spavinaw granites and is rare.

Amax DAC-6, SE SE SW 19-20N-24E, Delaware County

Dr-7-1, core, 1450 feet

RHYOLITE PORPHYRY: Groundmass, 69.1; plagioclase, 15.8; feldspar alterations, 6.5; chlorite, 4.0; iron ore, 1.5; calcite–dolomite, 1.4; apatite, 0.4; sphene–leucoxene, 0.2; zircon, tr.

Altered phenocrysts of sodic andesine–calcic oligoclase are set in a hematite-rich quartz–feldspar groundmass. Perthite occurs as small, sparse phenocrysts and as minor rims around some plagioclase. Chlorite is associated with sphene–leucoxene in pseudomorphs. These pseudomorphs contain inclusions of apatite. Magnetite is partly intergrown with leucoxene and contains zircons as partial or total inclusions. Calcite–dolomite is in masses associated with chlorite and in veins. Mostly plagioclase alteration is sericite, but some fine clay mats are also present. Grain size: phenocrysts, 4 mm; groundmass, microcrystalline. Texture: porphyritic–felsophyric.

The rhyolite is part of the southern tract of the Washington Volcanic Group and is typical of volcanic rocks in the area.

Sinclair Oil & Gas 19 Hartley, 18-22N-3W, Garfield County

Gf-1-1, cuttings, 5542–5561 feet
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 granites of the Central Oklahoma Granite Group. The samples are poor, but the distinctive microcline and texture are definitely characteristic of the group.

Cameron (Hoke) 3 Ford, 31-23N-3W, Garfield County

Gf-2-1, cuttings, 6610 feet, cir.

GRANITE: Microcline, plagioclase, quartz, chlorite, feldspar alterations, sphene–leucoxene, calcite, iron ores, zircon, apatite.

Microcline is partly perthitic and is generally fresh. Plagioclase is albite–oligoclase and is turbid with alteration material. Quartz is extensively strained. Shear linears are common with brecciation of the parent granite. All former biotite is now replaced by chlorite with attendant fine sphene–leucoxene granules. Sphene–leucoxene also replaces sphene wedges. Most cutting chips are single mineral fragments, but those with a textural relationship appear to be hypidiomorphic. Grain Size: average: 2+ mm. Texture: hypidiomorphic–cataclastic.

The general petrographic characteristics clearly relate this rock to the Central Oklahoma Granite Group.

Pan American 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 parts of the groundmass. Abundant phenocrysts are typically volcanic rocks. 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. Grain size: phenocrysts, 2.25 mm; groundmass, microcrystalline to 0.3 mm variable. Texture: porphyritic–crystalloblastic.

A rhyolite of the Washington Volcanic Group, this well is only about 3 miles from the Pan American 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 are believed to be related to the intrusion of this younger granite.

Anderson Prichard 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 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 ages of 1260 ± 51 m.y. on the feldspar and 1228 ± 56 m.y. on total rock sample.

Continental Oil 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 in color. 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 Refg. et al. 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 former volcanic rock 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 are also present along with apparent flow bands. Thin quartz veins are 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 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 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 sign of later thermal activity. The well is located about 11 miles due east of the granite in Ky-1, and this granite is interpreted as the agent for the metamorphism.

Pan American 1 Tackett, 28-8N-23E, Le Flore County

Lf-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 1239 ± 52 m.y. This granite is interpreted as the agent for the alteration–metamorphism of the rhyolite in Hk-1 about 3 miles to the west-southwest.

T. E. Berry 1 Cook, 6-16N-6E, Lincoln County

Ln-1-1, cuttings, 5865–5875 feet

GRANITE: Perthite, 56; quartz, 22; plagioclase, 12; hornblende, 4; chlorite, 2; feldspar alterations, 1; biotite, tr.; opaque minerals, tr.; sphene–leucoxene, tr.; calcite, tr.; apatite, tr.; zircon, tr.

The cutting chips are all less than 2 mm in length. Perthite is turbid with hematite dust and vacuoles but is generally fresh. Plagioclase is in the albite composition range. It contains fibrous sericite mats but is locally quite fresh. Hornblende is a brownish-green common type, is mostly in small crystals partially showing a sieve structure, and is partly altered to chlorite. A small amount of red-brown biotite is present. Quartz is partly intergrown with perthite but is mostly in larger unstrained discrete crystals. Grain size: 2+ mm. Texture: hypidiomorphic to micrographic.

The well drilled into rocks of the Spavinaw Granite Group. It is on the flank of a large gravity minimum believed to be underlain by these granites.

Spavinaw outcrop, 15-22N-21E, 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 lent 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 1326 ± 52 m.y. by the Rb/Sr method was obtained on this sample.

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

My-0-1, 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 conforms closely 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.

J. L. Milligan 1 Lee, 17-23N-19E, Mayes County

My-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 similar to the outcrop about 15 miles to the southeast.

Davis & Miller 1 Knight, 34-23N-21E, Mayes County

My-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 4 miles north of the outcrop.

J. Bander 1 Brixey, 15-23N-20E, Mayes County

My-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. Delicate micrographic intergrowths 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 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.

Henderson 1 Carter, 26-19N-18E, Mayes County

My-7-1, cuttings, 1970–1975 feet

RHYOLITE PORPHYRY: Groundmass, plagioclase, perthite, chlorite, iron ore, amphibole, calcite, feldspar alterations, apatite, zircon.

Phenocrysts of perthite and plagioclase are set in a fine quartz–feldspar groundmass showing some patch polarization. Feebly birefringent chlorite masses are surrounded by calcite and are the replacement of original femic phenocrysts. Iron-ore granules are common and are associated with sphene–leucoxene. Relicts of a pale amphibole are present in some chlorite masses. Plagioclase is sodic oligoclase and contains irregular sericite flakes and some epidote granules. Grain size: phenocrysts, 3+ mm; groundmass, microcrystalline. Texture: porphyritic–felsophyric.

The rhyolite is part of the Washington Volcanic Group and is one of the four samples penetrated in the area to define the central tract of rhyolites.

Amax SP-2, 8-22N-20E, Mayes County

My-8-1, core, 1816 feet

MICROGRAPHIC GRANITE PORPHYRY: Micrographic quartz–perthite, 44.9; plagioclase, 29.5; perthite; 12.6; chlorite, 6.2; epidote, 2.3; iron ore, 1.6; calcite, 1.1; leucoxene, 0.9; feldspar alterations, 0.6; apatite, 0.2; tremolite–actinolite, 0.2; zircon, tr.

Phenocrysts of sodic andesine–calcic oligoclase are set, together with perthite, in a finely micrographic quartz–perthite groundmass. Local coarsenings in the groundmass give rise to discrete quartz and perthite. Chlorite with minor tremolite–actinolite completely replaces a former femic mineral. Calcite is associated with the chlorite. Magnetite is intergrown in part with leucoxene after ilmenite. Epidote granules are common as inclusions in plagioclase. Epidote also occurs in large late-formed intergranular crystals. Apatite is common. Perthite is turbid with hematite dust and vacuoles. Grain size: phenocrysts, 4+ mm; groundmass, 1 to 1.5 mm average. Texture: porphyritic–micrographic.

The granite is typical of the Spavinaw Granite Group. The feldspar yielded an Rb/Sr age of 1317 ± 22 m.y.

Amax SP-3, 31-22N-21E, Mayes County

My-9-1, core, 1425 feet

MICROGRAPHIC GRANITE PORPHYRY: Micrographic quartz–perthite, 48.2; plagioclase, 23.3; perthite, 10.8; chlorite, 7.9; feldspar alterations, 6.0; leucoxene, 2.0; calcite, 1.0; apatite 0.5; iron ore, 0.3; zircon, tr.; epidote, tr.

Phenocrysts of calcic oligoclase and lesser perthite are set in a micrographic quartz–perthite groundmass. The plagioclase is turbid with fine sericite but contains little epidote. Perthite contains evenly distributed hematite dust and vacuoles. Chlorite is associated with leucoxene and calcite in clots. Apatite is common. The micrographic intergrowth is well defined and partly spherulitic. Hematite and leucoxene replace the former magnetite–ilmenite. Grain size: phenocrysts, 4.5 mm; groundmass, 1.5 mm average. Texture: micrographic–porphyritic.

The sample is typical of the Spavinaw Granite Group.

Amax SP-4, 31-23N-19E, Mayes County

My-10-1, core, 1883 feet

MICROGRAPHIC GRANITE PORPHYRY: Micrographic quartz–perthite, 44.7; plagioclase, 21.9; perthite, 19.8; chlorite, 4.9; feldspar alterations, 4.1; epidote, 1.6; calcite, 1.1; iron ore, 0.8; leucoxene, 0.8; apatite, 0.2; zircon, tr.

Phenocrysts of perthite and sodic andesine–calcic oligoclase are set in a well-defined micrographic groundmass. Plagioclase contains considerable sericite in disseminated shreds as well as epidote granules and some clay patches. Perthite contains some epidote granules and is turbid with hematite dust and vacuoles. Epidote, partly with pistachio-green color, is in large, well-formed intergranular crystals, associated in part with quartz and chlorite. Grain size: phenocrysts, 6 mm; groundmass, 1.5 to 2 mm average. Texture: micrographic–porphyritic.

The well cored rock typical of the Spavinaw Granite Group.

Amax SP-1, 13-22N-19E, Mayes County

My-11-1, core, 1809 feet

MICROGRAPHIC GRANITE PORPHYRY: Micrographic quartz–feldspar, 43.8; plagioclase, 27.7; perthite, 13.8; chlorite, 6.8; epidote, 2.2; feldspar alterations, 1.9; tremolite–actinolite, 1.4; iron ore, 0.9; sphene–leucoxene, 0.9; apatite, 0.3; calcite, 0.3; zircon, tr.

Phenocrysts of perthite and plagioclase are set in a partly spherulitic, micrographic quartz–perthite intergrowth. Plagioclase contains clay-sericite and discrete epidote granules and is calcic oligoclase–sodic andesine in composition. Perthite is turbid with hematite dust and vacuoles. Chlorite and associated tremolite–actinolite replace the former femic mineral completely. Magnetite is fresh, but ilmenite is now mostly altered to sphene–leucoxene. Apatite is in numerous well-formed prisms generally associated with chlorite. Grain size: phenocrysts, to 8 mm; groundmass, 1.5 mm average. Texture: porphyritic–micrographic.

The well cored rock typical of the Spavinaw Granite Group.

USSRAM Explor. Co. 1 Marshall, 23-13N-19E, Muskogee County

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

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 continuity. 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. As in other examples of the Washington Volcanic Group south of the Spavinaw granites, extrusive features are lacking.

W. H. Pine 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.

This fine-grained porphyry is interpreted 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 in most of the groundmass obscures textural relations. 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 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 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 parts 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.

Oklahoma Nat. Gas 1 Hardrow, 15-23N-2W, Noble County

Nb-3-1, cuttings, 5508 feet

GRANITE: Plagioclase, 40.0; quartz, 27.7; perthite, 18.9; feldspar alterations, 7.7; biotite, 2.8; chlorite, 2.5; sphene–leucoxene, 0.2; iron ore, 0.1; apatite, tr.

Plagioclase ranges from intermediate oligoclase to intermediate albite in composition and is in part extensively altered, particularly the oligoclase. Microcline is partly perthitic and fresh. Biotite is a deep reddish-olive-brown color and is strongly pleochroic. Chlorite replaces the biotite extensively and is accompanied by sphene–leucoxene. Sphene wedges are now replaced by calcite and sphene–leucoxene. Apatite is common as needle inclusions in biotite. Feldspar alterations are sericite and epidote accompanied by hematite. Iron ores are rare. Grain size: phenocrysts, to 1 cm; groundmass, 3 to 4 mm. Texture: hypidiomorphic.

The relatively coarse two-feldspar granite is typical of rocks drilled along the Nemaha Ridge zone. It is part of the Central Oklahoma Granite Group. Rb/Sr ages on three samples yielded a biotite age of 1318 ± 21 m.y., a feldspar age of 1192 ± 24 m.y., and a whole-rock age of 1381 ± 29 m.y.

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 in optically continuous areas of 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 Volcanic Group.

Cities Service 5 Farley, 19-11N-2W, Oklahoma County

Ok-1-2, cuttings, 8275–8285 feet
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, lineated aggregates. Microcline and microcline perthite are fresh, with only 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-1-3, 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.

These samples are from one of the two wells in the Oklahoma City field that penetrated basement rock. The feldspar in the granite yielded an Rb/Sr age of 1266 ± 67 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 only in this well in northeastern and central Oklahoma. The determined age should be close to the time of crystallization of the original granite. The age of metamorphism is unclear, but it is almost certainly Precambrian and not related to the faulting that bounds the east side of the Oklahoma City structure. The age of the diabase is unknown. The rock was intruded after the shearing and metamorphism and before the transgression of the Paleozoic seas.

Macklanberg-Duncan 1-A Disposal, 15-12N-3W, Oklahoma County

Ok-2-1, cuttings, 9832–9848 feet

SHEARED GRANITE GNEISS: Microcline perthite, plagioclase, quartz, hornblende, biotite, iron oxides, calcite, feldspar alterations, apatite.

Relict eyes of feldspar are surrounded by highly sheared and lineated quartz and accessory minerals. The accessory minerals are rather abundant, and apatite, in particular, in numerous small crystals. The sheared parts are composed mostly of fine-grained aggregate of quartz with lesser feldspar. Hornblende is a common type and is partly replaced by calcite. Most of the relict feldspar eyes are strained. Biotite is a reddish-brown type, associated with hornblende and generally in small crystals. Iron oxides are relatively abundant. Grain size: 2+ mm. Average: variable. Texture: cataclastic.

This well is one of two drilled to basement in the Oklahoma City Field. The sheared nature of the granite in both wells suggests that this is a regional feature of the basement along this part of the Nemaha Uplift.

Hamon and Cox 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 parts 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 parts 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 suggest that it is related to the outcrop samples of the Spavinaw Granite Group.

Mid Continent 9 Daniels, 12-13N-13E, Okmulgee County

Om-2-1, cuttings, 3560–3570 feet
Om-2-2, cuttings, 3580–3593 feet

MICROGRAPHIC GRANITE PORPHYRY: Micrographic quartz–feldspar; perthite; quartz; plagioclase; 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 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 is 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 2 Well 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 than the plagioclase. 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, as former femic phenocrysts. Chlorite is also disseminated through groundmass. Epidote crystals are associated with chlorite and replace some feldspars. Zircon and apatite are unusually abundant. Grain size: phenocrysts, 2.2 mm; groundmass, microcrystalline. Texture: porphyritic–felsophyric.

This rhyolite of the Washington 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 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. It is a near-spherulitic type. The feldspars of the groundmass are turbid with hematite dust. Phenocrysts are extensively sericitized and altered. Pyroxene crystals, 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. It is similar to the granite, bearing the same pyroxene and with the feldspars having the identical ragged and turbid appearance. It differs in containing much less hematite and only minor quartz. 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 about 8 miles southeast of another pyroxene granite (Ck-3).

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

Os-1-1, cuttings, 3215–3230 feet
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.

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 Volcanic Group lying some 2 to 3 miles southeast of the inferred contact of the microgranite.

Okmar Oil, S-1 Boren, 34-22N-10E, Osage County

Os-2-0, cuttings, 3395–3400 feet

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

This well did not report basement rock, but the thin section cut from the interval suggests that 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 Volcanic Group.

Phillips Petr. 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 and are 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 has associated femic minerals, some of which 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 Volcanic Group.

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

Os-4-1, cuttings, 2605–2610 feet
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 generally rounded glomerophenocrysts. Calcite replaces feldspar along a vein forming a pseudointergrowth with quartz. Feldspar contains only minor clay-mica alterations but is clouded by vacuoles and hematite dust. Chlorite–biotite is in 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 have resorbed, ragged margins. Grain size: phenocrysts, 4+ mm; groundmass, 0.5 mm. Texture: porphyritic–hypidiomorphic–acicular.

This well penetrated typical rock of the Osage Microgranite.

Pure Oil 190 Osage–Hominy, 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 apparent in both pseudomorphs of former femic minerals and in irregular masses of shreds in the groundmass. Sphene–leucoxene replaces a titaniferous iron oxide. Grain size: phenocrysts, 4+ mm; groundmass, 0.2 mm average. Texture: porphyritic–hypidiomorphic–acicular.

This well penetrated typical rock of the Osage Microgranite.

Keener Oil 29 Osage "A," 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 shards have been preserved through devitrification and are largely sericitized. Fragments of rhyolite groundmass roughly the size of phenocrysts (1.5 mm) are found 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 Volcanic Group.

Mid-Continent 1 Osage Tr. 201, 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 Microgranite.

Ohio Oil S-1 Osage B-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 perthite plagioclase, quartz, and 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 Volcanic Group.

Pure Oil 192 Osage–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 are 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 Microgranite. The minor plagioclase was encountered in only one other well (Os-23).

Texas Co. 1-5 Smith Tract "A" 26, 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 led 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 are magnetite, apatite, and zircon. Grain size: phenocrysts to 2.5 mm; groundmass, average microcrystalline. Texture: porphyritic–felsophyric.

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

Cities Service 1-5 S. Barnsdall Unit (Smith), 8-23N-11E, Osage County

Os-11-1, cuttings, 3013–3025 feet

RHYOLITIC ARKOSE: Lithic 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 approximate because of difficulties in distinguishing rhyolite fragments from the cementing matrix.)

The rock is composed almost wholly of rhyolite fragments. 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 present; some are 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 Volcanic Group and not an arkosic detrital zone of early Paleozoic age.

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

Os-12-2, cuttings, 3029–3034 feet
Os-12-1, cuttings, 3013–3029 feet

RHYOLITE PORPHYRY: Groundmass; perthite; quartz; feldspar alterations; plagioclase; opaque minerals; calcite; zircon.

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 in appearance, composed of very small, granular quartz–feldspar having a common optic orientation. Hematite dust is finely disseminated in groundmass. Muscovite is in books with opaque minerals, probably after biotite. Part of the perthite is an antiperthite with thin K-feldspar replacements in plagioclase crystals. Sericite as partial replacements of feldspars is common. Grain size: phenocrysts, 1.5 mm; groundmass, average microcrystalline. Texture: porphyritic–felsophyric.

This well penetrated a rhyolite of the Washington Volcanic Group.

Gled Oil 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 Microgranite, this rock is tentatively placed in the Washington Volcanic Group. The evidence, however, is not too firm, and it could be the chilled phase of the microgranite.

Moore Oil & Ohio Oil 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. The quartz is somewhat acicular, and the whole rock is similar to 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 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: the larger crystals have well-defined subhedral outlines, and smaller crystals are resorbed, with rounded outer margins. The groundmass contains abundant ragged hematite dust. Feldspars contain little recognizable alteration 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 Volcanic Group was drilled very near the inferred southeast boundary of the Osage Microgranite.

Big Four Petr. (Anderson) 5 Bird, 33-22N-7E, Osage County

Os-16-1, cuttings, 3760–3790 feet
Os-16-2, cuttings, 3790–3810 feet
Os-16-3, cuttings, 3810–3825 feet
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 abundant, locally coarse sericite both in the groundmass and mottled feldspar replacement. Quartz phenocrysts are subhedral to rounded and embayed. Embayments are deep; and narrow, wormlike 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 that converted so much of the groundmass to sericite–quartz. The rock is a member of the Washington Volcanic Group.

F. De Mier 1–A Zink (Osage), 5-21N-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.

The highly altered rhyolite porphyry is 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 Volcanic Group.

Amerada Petr. 1 Hardy, 7-23N-11E, Osage County

Os-18-1, cuttings, 2349–2359 feet
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 is generally clouded. Sphene and sphene–leucoxene are present, the sphene–leucoxene after titaniferous magnetite. Grain size: to 4 mm; groundmass, 0.4 mm average. Texture: porphyritic–hypidiomorphic–acicular.

This well penetrated Osage Microgranite and is only 1 mile west of a well (Os-11) penetrating rock belonging to the Washington Volcanic Group.

Marland & Gled 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 Microgranite.

Red Bank Oil 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 has 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 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 Oil WS–1 Botts, 14-26N-6E, Osage County

Os-21-1, cuttings, 4470–4475 feet
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 abundant and suggest 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. The diversity of feldspars also supports 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 Volcanic Group.

De Mier Oil 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 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 Volcanic Group.

Norbla Oil 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 parts of the perthite phenocrysts and is found 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 replaces 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 Microgranite. The feldspar yielded an Rb/Sr age of 1281 ± 48 m.y.

Gulf Oil 65 Boston, 1-21N-7E, Osage County

Os-24-2, cuttings, 2970–3000 feet
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.

As in rhyolites in so many wells to the southwest of the area of the Osage Microgranite, there are a number of features in this sample that are also found in the microgranite. The delicate acicular quartz rods that are common even in closely spaced samples such as this rhyolite, however, show that all characters are not consistent in the rhyolites.

The well penetrated rock interpreted as belonging to the Washington Volcanic Group.

Bay Oil 1 Osage (White), 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 phenocrysts 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 Volcanic Group.

Southern Union Prod. 1-C Atchison, 5-20N-11E, 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 6 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 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 cores 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 abundant as large crystals associated with chlorite and as 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 Microgranite. A whole-rock Rb/Sr age of 1183 ± 46 m.y. was obtained from this sample.

J. G. Buell 14 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 Microgranite.

Texas Co. 13 SWD Bennett, 12-23N-7E, Osage County

Os-29-1, cuttings, 3470–3510 feet
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–sericite are set in a groundmass of devitrified quartz–feldspar. The groundmass texture varies considerably in texture and grain size. Clots of accessory minerals consisting of chlorite–apatite–iron oxides with some sphene–leucoxene are present. Some chlorite masses have 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 Volcanic Group and is near the western margin of the Osage Microgranite.

Phillips 1–SWD Higgens "A," 23-25N-8E, Osage County

Os-30-1, cuttings, 3633–3652 feet
Os-30-2, cuttings, 3652–3664 feet

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

This is 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; microcrystalline average. Texture: porphyritic–eutaxitic.

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

Cities Service 1-SWD Osage 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 that causes varying devitrification patterns is also noted. Amygdule 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 Volcanic Group. A date of 1233 ± 50 m.y. was obtained on the whole rock by the Rb/Sr method.

Sunray DX 8 Osage, 17-21N-10E, Osage County

Os-34-1, cuttings, 3375–3380 feet
Os-34-2, cuttings, 3385–3390 feet

RHYOLITE ARKOSE: Lithic fragments, perthite, quartz, plagioclase, cementing matrix, carbonate, epidote, sericite, chlorite, sphene–leucoxene, iron oxides, zircon.

Various clasts of rhyolitic debris are set in a fine chertose matrix—apparently silica. Many of the grains "float" in the cement matrix, not touching, particularly in the coarser intervals. The lithic debris is all rhyolitic in origin and highly diverse in texture. The crystal fragments are those found in rhyolites. The amount of cementing matrix varies considerably. There are minor quartz–feldspar veinlets in the upper interval, and epidote is common as a secondary mineral in the lower. Sericite and associated chlorite are present as apparent void fillings. Calcite in veins and masses replaces irregularly. Grain size: average 0.3 to 0.7 mm. Texture: clastic.

This is one of two wells penetrating essentially identical rhyolite arkoses. The other is Os-11, about 15 miles to the north. Both wells are interpreted as penetrating basement clastic rocks rather than basal Cambrian sediments because of the occurrence of crystalloblastic epidote and quartz–feldspar veins, neither of which is reported in the Paleozoic sedimentary rocks, although both are common in the rhyolite.

Texaco 1 Osage "C," 24-20N-11E, Osage County

Os-35-1, core, 2685–2690 feet

RHYOLITE PORPHYRY: Groundmass, 89.2; perthite, 6.3; plagioclase, 3.2; quartz, 1.9; feldspar alterations, 0.3; leucoxene, 0.1; chlorite, tr.; iron oxides, tr.; zircon, tr.; apatite, tr.

Phenocrysts of perthite, plagioclase, quartz, and sparse chlorite pseudomorphs are set in a very finely banded quartz–feldspar groundmass. The banding is marked by coarser segregations and thin quartz bands. Vague relict eutaxitic structure is present. Sericitic alterations are mostly in plagioclase but are also in thin veinlets roughly normal to banding. These veinlets have in part a sinuous course on a microscale—similar to stylolites—but others are quite straight. Wedges that appear to have been sphene are now sphene–leucoxene and chlorite. Sparse chlorite and a brownish secondary mica replace a former femic mineral. Grain size: phenocrysts, 2 mm; groundmass, microcrystalline. Texture: porphyritic–relict–eutaxitic(?).

The extrusive features are common in the rhyolites of this area of the Washington Volcanic Group. The whole rock yielded an Rb/Sr age of 1286 ± 24 m.y.

Sunray DX S–1 Osage, 24-24N-9E, Osage County

Os-36-1, cuttings, 3320–3325 feet

MICROGRANITE PORPHYRY: Quartz–feldspar groundmass, 74.6; perthite, 12.4; biotite, 6.7; plagioclase, 2.2; chlorite, 1.3; calcite, 1.2; leucoxene, 1.0; iron oxides, 0.4; hornblende, 0.1; quartz, 0.1; riebeckite, tr.; zircon, tr.; apatite, tr.; fluorite, tr.; epidote, tr.

Phenocrysts of perthite are set in a finely xenomorphic equigranular groundmass. Quartz phenocrysts are sparse. Plagioclase is found as sparse cores in some perthite phenocrysts. Chlorite and a secondary biotite are common and abundant, mostly after large masses of a former femic mineral. Only the smallest relicts of riebeckite remain. Zircons are numerous, partly as exceptionally slender rods. Fluorite occurs as sparse segregations. Carbonate is in irregular blebs and small, rather evenly distributed rhombs. The chlorite appears to be most common near cores of the larger masses, and the reddish-yellow secondary biotite near the margins and in discrete smaller masses. The biotite may be after riebeckite, and the chlorite after common hornblende. Small, pale, common hornblende crystals are scattered through the groundmass. Grain size: phenocrysts, 4+ mm; groundmass, 0.2 average. Texture: porphyritic–xenomorphic.

This well is most significant because it was drilled more nearly in the center of the Osage Dome than any other. The rock texture is different from other rocks of the unit and contains the only primary femic mineral found in the Osage Microgranite.

Pure Oil 201 Osage-Hominy, 8-23N-8E, Osage County

Os-37-1, cuttings, 3165 feet, cir.

MICROGRANITE PORPHYRY: Groundmass, perthite, quartz, chlorite, iron oxides, sphene–leucoxene, feldspar alterations, zircon, apatite.

Phenocrysts of perthite and lesser quartz are set in a fine quartz–perthite groundmass carrying the characteristic acicular rods of quartz. Perthite is turbid with vacuoles and hematite dust but is generally fresh. The quartz phenocrysts have a rim of optically continuous groundmass quartz. Chlorite is particularly common in the groundmass as irregular masses and as larger pseudomorphs. Grain size: phenocrysts, 4+ mm; groundmass, 0.3–0.5 mm average. Texture: porphyritic, hypidiomorphic–acicular.

The rock is typical of the Osage Microgranite. The well was drilled close to several wells penetrating identical rock.

Pure & Sinclair 196 Osage-Hominy, 8-23N-8E, Osage County

Os-38-1, cuttings, 3006 feet, cir.

MICROGRANITE PORPHYRY: Groundmass, perthite, quartz, chlorite, sphene–leucoxene, iron ore, calcite, feldspar alterations, epidote, apatite, zircon.

Phenocrysts of perthite and sparse plagioclase are set in a quartz–feldspar groundmass with a characteristic acicular appearance of the quartz. Chlorite replaces former femic minerals as well-formed pseudomorphs and is also found as fine irregular masses of shreds in the groundmass. Calcite replaces irregularly around some accessory mineral clots. Magnetite is in rounded granules as well as in ragged patches in the groundmass. Perthite is fresh with dusted vacuoles and hematite. Grain size: phenocrysts, 6+ mm; groundmass, 0.4–0.6 mm average. Texture: porphyritic–hypidiomorphic–acicular.

The rock is typical of the Osage Microgranite. The well was drilled close to several wells penetrating identical rock.

Appleton 1 Hickory Creek, 22-27N-8E, Osage County

Os-39-1, cuttings, 3640–3645 feet
Os-39-2, cuttings, 3665–3670 feet
Os-39-3, cuttings, 3690–3700 feet
Os-39-4, cuttings, 3795–3798 feet
Os-39-5, cuttings, 3798 feet

RHYOLITE PORPHYRY: Groundmass, quartz, plagioclase, perthite, chlorite, sphene–leucoxene, iron ore, epidote, feldspar alterations, apatite.

All five intervals are essentially identical; cutting chips are fine throughout. Phenocrysts of quartz, perthite, and plagioclase are set in an irregularly textured groundmass of quartz–feldspar. The texture ranges from highly spherulitic to relict eutaxitic to microcrystalline (chertose). Quartz is abundant as phenocrysts. Feldspars have been irregularly replaced by sericite and epidote. Masses of chlorite and sphene–leucoxene replace a former femic mineral. Grain size: phenocrysts, 2+ mm; groundmass, irregular. Texture: porphyritic–spherulitic–relict–eutaxitic.

The well penetrated normal rhyolite just south of the Labette Fault. Wells drilled north of the fault penetrate metarhyolite. The samples are typical of the Washington Volcanic Group.

Atlantic Ref. 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: prophyritic–acicular–felted.

This well drilled a rhyolite porphyry of the Washington Volcanic Group.

Sunray DX 21-NW-32-21-12, 32-21N-12E, Osage County

Os-41-1, cuttings, 2560–2575 feet
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 are set in a 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 incipient amygdules. Grain size: phenocrysts, 2.0 mm; groundmass, microcrystalline average. Texture: porphyritic–eutaxitic.

This welded tuff is an example of the Washington Volcanic Group and is in an area in southeastern Osage County where extrusive rhyolites are common.

Gulf Oil 3 Price Unit 1-5, 30-25N-11E, Osage County

Os-42-1, cuttings, 3195 feet, cir.

RHYOLITE PORPHYRY: Groundmass; plagioclase; perthite; feldspar alterations; calcite–siderite; iron oxide; sphene–leucoxene; zircon; chlorite; quartz.

Phenocrysts of perthite, plagioclase, and lesser quartz are set in a groundmass of felsophyric quartz–feldspar. Sericitic alterations replace parts of the phenocrysts and groundmass. Calcite is an irregular replacement and is associated in one chip with fine siderite. Magnetite grains are associated with accessory minerals and sphene–leucoxene after ilmenite. Areas in the groundmass have patch polarization. Grain size: phenocrysts, 2 mm; groundmass, 0.04 mm average. Texture: porphyritic–felsophyric.

The well penetrated rhyolite of the Washington Volcanic Group.

Producers 2 Osage (Pettit), 20-23N-8E, Osage County

Os-43-1, cuttings, 2618–2726 feet

MICROGRANITE PORPHYRY: Quartz–perthite groundmass, 62.0; perthite, 27.7; quartz, 3.6; chlorite, 3.3; plagioclase, 1.4; calcite, 1.0; iron oxides, 0.3; zircon, 0.3; leucoxene, 0.1; apatite, 0.1; feldspar alterations, tr.

Abundant phenocrysts of perthite and quartz are set in a quartz–perthite groundmass with characteristic acicular quartz rods. Plagioclase of indeterminate composition is found as a large phenocryst with a partial perthite rim. Chlorite is found as large masses partly associated with leucoxene and as small shreds in the groundmass. Quartz phenocrysts have an optically continuous rim of groundmass quartz surrounding them. Zircons are abundant as larger stubby crystals and smaller very slender rods. Grain size: phenocrysts: 4+ mm; groundmass, 0.4–0.6 mm average. Texture: porphyritic–hypidiomorphic–acicular.

The rock is typical of the Osage Microgranite. The well was drilled close to several wells penetrating identical rock.

City of Miami 3 Goodrich Rubber, 24-28N-22E, Ottawa County

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, others nearly cuniform. Chlorite is unusually sparse. Sphene–leucoxene replaces titaniferous magnetite. Several plagioclase crystals have a deep-reddish perthite rim. Grain size: phenocrysts to 2.5 mm; groundmass, 1.1 mm average. Texture: micrographic–porphyritic.

This well penetrated an example of the femic-poor variety of the Spavinaw Granite Group.

Commerce Mining & Royalty 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 low 2V suggestive of sanidine. One patch is unusually clear and has a high 2V and a suggestion of microcline twinning. 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 that of the other well and is typical of the Spavinaw Granite Group.

Commerce Mining & Royalty 1 Bird Dog Mine, 13-29N-22E, Ottawa County

Ot-3-1, cuttings, 1190 feet
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.

The lower interval is much less altered than the upper. In both intervals the 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 an example of the femic-poor varieties of the Spavinaw Granite Group.

American Zinc Demo 2 (A2-2), 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 vacuoles; 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 Demo 7 (A2-7), 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 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 a 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 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 P-5 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 ill defined and is composed chiefly of feldspar and tremolite–actinolite with lesser amounts of micas, opaque minerals, and sphene–leucoxene. Certain zones are silicified, are 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.

This well contained andesite related to the Washington Volcanic Group and is some 20 miles east of the welded andesite tuffs in Craig County (Cg-1, Cg-2).

Eagle Picher 43-C 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 includes 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 Oil & Gas 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 with 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 Volcanic Group. An Rb/Sr age on total rock yielded an age of 1224 ± 51 m.y.

Watchorn Oil & Gas 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 and 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 as 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 clear. 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, penetrated rhyolites with an unusual groundmass texture. The rock is interpreted as a metamorphosed equivalent of the Washington Volcanic Group.

Tidal-Osage 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. Phenocryst feldspars 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 Volcanic Group near the inferred southern margin of this group.

Minnehoma 1 Richards, 9-20N-8E, Pawnee County

Pw-4-1, cuttings, 3052–3058 feet
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 irregularly shaped perthite phenocrysts are rounded to elongate. Micaceous masses replace parts of the quartz–feldspar groundmass. Iron oxides are not in phenocrysts but occur 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 Volcanic Group shows relict extrusive characters.

Porter Oil & Gas 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 10 optic units 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. Grain size: phenocrysts, 11.0 mm; groundmass, 0.07 mm average. Texture: porphyritic–granoblastic.

This rock, as with Pw-2, is interpreted as the metamorphosed equivalent of the Washington 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 1317 ± 22 m.y.

Deep Rock Oil 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 Petr. 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.

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 abundant hematite dust. Discrete epidote crystals are 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 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 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 is 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, 19-7N-5E, Pottawatomie County

Pt-1-1, cuttings, 7755–7775 feet

GRANITE: Plagioclase, 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 and 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.

The granite is placed in the Central Oklahoma Granite Group on the basis of the occurrence of two feldspars and the texture. Mild metamorphic effects, commonly shown by the rocks of the Eastern Arbuckle Province north of the Tishomingo Anticline, are lacking in this sample.

Reed & Son 1-A Koenig, 27-19N-17E, Rogers County

Rg-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 nonopaque minerals. The microcline perthite is clouded with alterations and contains disseminated hematite. Oligoclase contains sericite flakes and less evenly disseminated hematite. The 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: 3+ mm. Texture: hypidiomorphic.

This well is unusual in that it contains microcline perthite and slightly strained discrete quartz. The well is 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 2 Grace Nichols "A," 25-22N-14E, Rogers County

Rg-2-1. cuttings, 2514–2575 feet
Rg-2-2, cuttings, 2575–2612 feet
Rg-2-3, cuttings, 2612–2636 feet
Rg-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, 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 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 Volcanic Group and is near the southern boundary with the Spavinaw Granite Group.

Smith & Daniels 2 Vierhiller, 36-21N-16E, Rogers County

Rg-3-4, cuttings, 2383–2478 feet
Rg-3-7, cuttings, 2500–2593 feet
Rg-3-6, cuttings, 2513–2516 feet
Rg-3-9, cuttings, 2611–2701 feet
Rg-3-11, cuttings, 2701–2787 feet
Rg-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, as small intergranular masses, and as replacement along cleavage cracks in feldspars. Epidote is common as a replacement mineral 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.

Rg-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.

Several cutting chips are composed of 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, in contrast 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.

Rg-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-formed 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 is 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 occurs 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 more plausible. An Rb/Sr determination on the feldspar from the granite yielded an age of 1247 ± 61 m.y. It is interesting to note the coarsening of groundmass grain size with depth, suggesting that the upper part is chilled.

[Possibly] Irvin 1 Cox, 23-20N-14E, Rogers County (?)

Rg-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 low. Iron dust is disseminated throughout, and clouding vacuoles 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 1 because it is not clear that the samples actually came from this well. The best indication is that they were obtained from the Irvin 1 Cox. In any case, the interpretation is not altered, and the rock is an example of the Spavinaw Granite Group.

USSRAM Explor. 1 Minor, 9-21N-15E, Rogers County

Rg-6-2, cuttings, 2180 feet

RHYOLITE PORPHYRY: Groundmass, 67.0; plagioclase, 15.1; perthite, 7.3; chlorite, 3.1; feldspar alterations, 3.0; calcite, 1.8; iron oxides, 1.3; epidote, 1.0; leucoxene, 0.6; zircon, tr.; apatite, tr.

Turbid phenocrysts of plagioclase and perthite are set in a finely felsophyric groundmass composed mostly of quartz–feldspar. Hematite is a heavy stain through the groundmass, particularly marked near magnetite grains. Chlorite pseudomorphs are associated with leucoxene after a former femic mineral. Epidote–calcite–chlorite masses irregularly replace parts of the rock. Calcite is found as small blebs throughout the groundmass. Plagioclase is calcic albite and carries sericite flakes and epidote granules as well as fine sericite mats. Grain size: phenocrysts: 3 mm. Average: 0.3. Texture: porphyritic–felsophyric.

The rhyolite is close to the inferred boundary between the Washington Volcanic Group and the Spavinaw granites. No metamorphic features are present in the rock.

Little Nick 1 Titus, 25-19N-17E, Rogers County

Rg-7-1, cuttings, 2040–2047 feet
Rg-7-2, cuttings, 2115–2119 feet

GRANITE: Perthite, 45.9; quartz, 34.2; plagioclase, 13.7; feldspar alterations, 4.5; chlorite, 1.6; hematite, 0.8; leucoxene, 0.3; zircon, tr.; apatite, tr.

Perthite is dusty with finely disseminated hematite and vacuole development. Plagioclase is calcic albite and contains abundant and rather evenly distributed sericitic shreds. Chlorite is after a former biotite and contains some large leucoxene masses. Zircons are large but sparse. Hematite is in secondary veinlets along feldspar cleavage. One very large plagioclase crystal indicates that the rock may be mildly porphyritic. There is some incipient micrographic development. Grain size: 2–3 mm. Texture: hypidiomorphic.

The granite lacks the micrographic texture typical of the Spavinaw Granite Group but is considered to be related to that group.

Magness (Keener) 1 Jones "A," 34-9N-6E, Seminole County

Sm-1-1, cuttings, 7290–9380 feet

GRANITE: Microcline, 41.5; quartz, 31.3; plagioclase, 22.6; feldspar alterations, 3.8; chlorite, 0.8; calcite, 0.4; leucoxene, 0.2; epidote, 0.2; biotite, 0.2; apatite, tr.; iron oxides, tr.; zircon, tr.

Microcline is partly perthitic and is lightly dusted with vacuoles and hematite. Plagioclase is near An_{10} and contains locally abundant epidote granules and sericite flakes and fibrous mats. Quartz is unstrained. Parts of the microcline are in a rude micrographic intergrowth with quartz. Chlorite with attendant leucoxene, epidote, and calcite replaces a former femic mineral. Magnetite is considerably altered to hematite. Sparse relicts of biotite are reddish brown. Zircon and apatite are abundant near magnetite granules. Grain size: average, 8+ mm. Texture: hypidiomorphic.

The two feldspars and general petrographic characteristics are very close to the average Central Oklahoma Granite Group.

Pawnee Petr. 1 Rentie, 23-9N-6E, Seminole County

Sm-2-1, cuttings, 7261 feet

GRANITE: Microcline perthite, 50.5; quartz, 34.2; plagioclase, 10.2; chlorite, 2.2; feldspar alterations, 2.0; leucoxene, 0.8; iron ore, 0.2; calcite, tr.; apatite, tr.; fluorite, tr.; zircon, tr.

The texture is erratic even in a single cutting chip grading from straight hypidiomorphic to micrographic. Sparse phenocrysts of quartz are present in some of the finer portions. Microcline is in string perthite and is very fresh. Plagioclase is calcic albite to oligoclase. Quartz is essentially unstrained. Clots of chlorite replace a former femic mineral, in part biotite, and are associated with fluorite and granular sphene–leucoxene. Sphene—leucoxene with calcite replaces sphene. Grain size: to 4 mm, erratic. Texture: micrographic–porphyritic–hypidiomorphic.

The rock is typical of the two feldspar granites of the Oklahoma Granite Group. The feldspar yielded an Rb/Sr age of 1242 ± 21 m.y.

T. J. Foster 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 rich in chlorite pseudomorphs. Both perthite and plagioclase (albite) phenocrysts are abundant. The perthite phenocrysts are wormy and rounded; the plagioclase is more nearly euhedral and is 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 are associated with chlorite and are present 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.

The pseudomorph-rich and quartz-poor character of this sample is typical of the Washington Volcanic Group in the central and southern tracts.

Oklahoma Nat. Gas Co. 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, and 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–granoblastic(?). The groundmass of this rhyolite may be either primary xenomorphic or reconstituted to a granoblastic mosaic.

The rhyolite is a member of the Washington Volcanic Group and may have been reconstituted by granite injection of the Central Oklahoma Granite Group. An Rb/Sr whole-rock determination yielded an age of 1246 ± 76 m.y.

Fred De Mier 3-A Bruner, 6-19N-12E, Tulsa County

Tu-1-1, cuttings, 2715–2720 feet
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 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 near the southern margin of the Washington Volcanic Group. The altered character may be due to the proximity of the Spavinaw granites.

Wilcox Oil & Gas 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 parts 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. 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 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 that this is a chilled phase.

Texaco 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.

There is great variation in texture and mineralogy of the cutting chips. All chips appear to be crystal to devitrified glassy tuff, but eutaxitic texture is poorly preserved. In crystal-rich parts, small quartz detritus is rounded and numerous. A few large quartz phenocrysts are present. The groundmass is deep reddish owing 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; groundmass, microcrystalline average. Texture: porphyritic–relict–eutaxitic.

This well penetrated extrusive rock of the Washington Volcanic Group.

Texas Co. 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 the textural interpretation difficult. Plagioclase phenocrysts are slightly clouded with alterations 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 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 is typical of the Spavinaw Granite Group.

Superior Oil 1 Blakemore, 26-21N-13E, Tulsa County

Tu-7-2, cuttings, 1407–1422 feet
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, possibly as 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.

This well penetrated rhyolite of the Washington Volcanic Group.

Superior Oil 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 present. 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.

This well is in the same section as Tu-7 and penetrated rocks of the Washington Volcanic Group.

Dotson et al. 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 not common. This well, together with others to the south and east, is characterized by this distinctive mineral.

Emrich & Austin 1 Carter, SW NE NW 5-16N-16E, Wagoner County

Wg-1-1, cuttings, 3090–3098 feet

MICROGRAPHIC GRANITE PORPHYRY: Perthite, 39.3; quartz, 26.5; plagioclase, 19.9; chlorite, 6.4; feldspar alterations, 5.8; iron oxides, 1.6; sphene–leucoxene, 0.4; apatite, 0.1; zircon, tr.

Phenocrysts of plagioclase and perthite are set in a rudely micrographic intergrowth. Chlorite, with attendant iron ores and sphene–leucoxene, replaces all the former femic mineral. Plagioclase phenocrysts are in the oligoclase range, are partly rimmed by perthite, and contain locally extensive sericitic alterations. Apatite and zircon are associated with the chlorite. Quartz is unstrained. Grain size: phenocrysts, 4 mm; groundmass, 1.0–1.5 mm. Texture: porphyritic–micrographic.

The well drilled rock typical of the Spavinaw Granite Group.

Little Nick 2 Weldon, NE SE SE 6-18N-18E, Wagoner County

Wg-2-1, cuttings, 2182–2190 feet
Wg-2-2, cuttings, 2215–2216 feet

RHYOLITE PORPHYRY: Groundmass, 69.0; plagioclase, 20.6; perthite, 4.8; chlorite, 1.7; sphene–leucoxene, 1.3; iron ore, 0.9; feldspar alterations, 0.8; calcite, 0.7; apatite, tr.; zircon, tr.

Phenocrysts of plagioclase, perthite, and chlorite pseudomorphs are set in a finely felsophyric groundmass of quartz–feldspar with some areas of patch polarization. The chlorite masses are associated with sphene–leucoxene, partly after ilmenite, and with apatite and zircon. Areas of sericitization are present irregularly through the groundmass. Plagioclase is albite–oligoclase and contains discrete sericite flakes. The perthite is dusted with vacuoles and hematite. Calcite is in irregular blebs. Grain size: phenocrysts, 2 mm; groundmass, 0.05 mm average. Texture: porphyritic–felsophyric.

The rhyolite drilled at this location is one of four penetrations that outline the central tract of the Washington Volcanic Group.

Henderson 1 Kelly, 18-17N-17E, Wagoner County

Wg-3-1, cuttings, 2095–2100 feet

PYROXENE RHYOLITE PORPHYRY: Groundmass, 72.4; plagioclase, 15.2; chlorite, 4.4; feldspar alterations, 2.8; perthite, 1.6; epidote, 1.2; sphene-leucoxene, 1.0; iron ore, 0.8; pyroxene, 0.2; apatite, 0.1; calcite, 0.1; zircon, tr.

Plagioclase phenocrysts, partly with a thin perthite rim, are set in a fine spherulitic groundmass of quartz–feldspar. Relicts of pyroxene are surrounded by chlorite. Chlorite masses contain granular sphene–leucoxene masses and are associated with apatite and iron oxides. Epidote granules are common in plagioclase phenocrysts. Quartz in the groundmass is both in spherulites with the feldspar and in coarser discrete crystals, essentially between the spherulitic masses. Grain size: phenocrysts: 2.5 mm; groundmass, 0.1 mm average. Texture: porphyritic–spherulitic.

Wg-3-2, cuttings, 2500–2505 feet

PYROXENE RHYOLITE PORPHYRY: Groundmass, 66.0; plagioclase, 20.4; chlorite, 4.3; feldspar alterations, 2.8; perthite, 2.8; epidote, 1.6; iron ore, 1.4; pyroxene, 1.3; sphene–leucoxene, 1.0; apatite, 0.2; calcite, 0.1; zircon, tr.

Phenocrysts of plagioclase (some with a perthite rim) are set in a finely spherulitic groundmass of quartz–feldspar. Pyroxene crystals are common, as are chlorite–epidote masses, as replacement of the pyroxene. Iron oxides and apatite are commonly associated with the femic minerals. The plagioclase shows variable replacement by epidote, is generally turbid with vacuoles, and is in the calcic oligoclase–sodic andesine range. A clot of microdioritic composition is in one cutting chip. Grain size: phenocrysts, to 3 mm; groundmass, microcrystalline. Texture: porphyritic–spherulitic.

The rhyolite is unusual because of the occurrence of pyroxene. The well drilled into the central tract of the Washington Volcanic Group. The whole rock yielded an Rb/Sr age of 1299 ± 26 m.y.

Henderson 1-A Cannon, 29-18N-18E, Wagoner County

Wg-4-1, cuttings, 1480–1485 feet
Wg-4-2, cuttings, 1680 feet, cir.

PYROXENE RHYOLITE PORPHYRY: Groundmass, 64.2; plagioclase, 18.8; feldspar alterations, 6.3; chlorite, 4.3; iron ore, 2.2; pyroxene, 1.9; perthite, 1.1; sphene–leucoxene, 0.6; apatite, 0.2; calcite, 0.2; epidote, 0.2; zircon, tr.

Phenocrysts of highly turbid oligoclase are set in a finely spherulitic groundmass of quartz–feldspar. Perthite is found as a minor rim on some plagioclase. Pyroxene is partly fresh and also completely replaced by chlorite with minor attendant sphene masses. Iron ores are common as phenocrysts and as dust disseminated in the groundmass. Chalcedonic quartz veins are present in some chips. Apatite needles are large, exceptionally long, and common. The plagioclase contains abundant sericite–epidote–zeolite as alteration products. Composite phenocrysts are common. Grain size: phenocrysts, 3.5 mm; groundmass, microcrystalline. Texture: spherulitic–porphyritic.

The rhyolite is part of the central tract of the Washington Volcanic Group.

Taylor 6-B Garrett, 3-27N-13E, Washington County

Ws-2-1, cuttings, 2280–2289 feet

WELDED RHYOLITE TUFF: Groundmass; perthite; plagioclase; quartz; lithic 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 delicate but is best shown in polarized light owing to devitrification patterns. The phenocrysts in some chips are exceptionally variable in 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 Volcanic Group.

Reinhart & Donovan 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 is in fibrous masses; both are secondary. Some deeper olive-green biotite may be primary. Thin quartz veinlets cut the 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 Volcanic Group.

Empire Gas & Fuel 3 McElmore, 25-25N-12E, Washington County

Ws-4-2, cuttings, 2340–2350 feet
Ws-4-3, cuttings, 2350–2368 feet
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 to the gray color of rhyolite. Chlorite and alteration micas are 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.

This well contained rhyolites that had features suggestive of a tuffaceous origin. Individually, the evidence is not strong, but jointly it cannot be disregarded. The rock is therefore interpreted as a tuffaceous rhyolite of the Washington Volcanic Group.

Barnsdall (Roxanna) 7 Rigdon, 30-28N-13E, Washington County

Ws-5-1, cuttings, 2548–2552 feet
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 the 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 Volcanic Group.

Empire Gas & Fuel 1 Thompson, 22-29N-13E, Washington County

Ws-6-1, cuttings, 2700–2703 feet
Ws-6-2, cuttings, 2772–2781 feet
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 that the rock has not been disturbed since extrusion except for simple devitrification. This rhyolitic rock is a member of the Washington Volcanic Group.

Greene & Jones S-1 Hildebrand, 20-26N-13E, Washington County

Ws-7-1, cuttings, 2167–2175 feet
Ws-7-2, cuttings, 2345–2357 feet
Ws-7-3, cuttings, 2221–2226 feet
Ws-7-6, cuttings, 2257–2262 feet

WELDED RHYOLITE TUFF: Groundmass, 88.3; perthite, 6.2; quartz, 2.1; plagioclase, 1.8; pyrite, 1.3; opaque minerals, tr.; feldspar alterations, tr.; sphene–leucoxene, tr.; zircon, tr.

A devitrified groundmass contains relict distorted shards contorted around phenocrysts of quartz, plagioclase, and perthite. Rude compositional banding is noted by much coarser bands within the generally submicroscopic devitrification products. Large opaque granules form phenocrysts, as well as being disseminated through the groundmass. Zircon is included within magnetite. Leucoxene replaces parts of the titaniferous magnetite. 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 Volcanic Group.

Bonaventure S-1 Chamberlain, 8-27N-14E, 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 parts of the plagioclase. Sphene and sphene–leucoxene replace titaniferous magnetite and are 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.

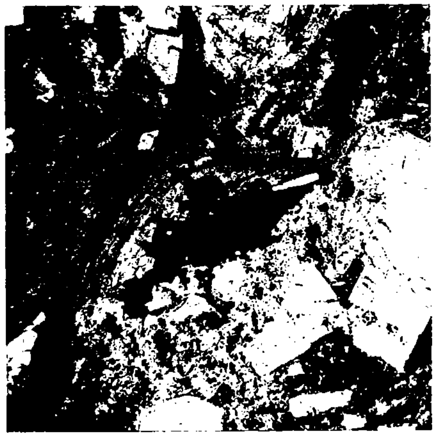
This well penetrated rhyolite of the Washington Volcanic Group.

PLATES

(Plate 1 is in pocket)

Plate 2—Photomicrographs of Washington Volcanic Group

1. Welded andesite tuff from Frankfort 1 Van Ausdel, 31-28N-20E, Craig County, Oklahoma (Cg-3-1); depth, 1,815–1,890 feet. Phenocrysts of plagioclase are set in a groundmass of devitrified glass showing well-defined eutaxitic structure. Andesites make up only a small percentage of the total volume of volcanic rocks, and samples from this well are the only ones that show a welded-tuff origin. Plane-polarized light; field width, 0.70 mm.
2. Pyroxene phenocrysts in andesite porphyry from Eagle Picher 1 Golden Hawk, 20-29N-23E, Ottawa County, Oklahoma (Ot-6-1); depth, 1,797 feet. Andesites typically carry a small percentage of femic phenocrysts or chlorite pseudomorphs. Plane-polarized light; field width, 0.70 mm.
3. Flow-banded rhyolite porphyry from Texaco 1 Osage C, 24-20N-11E, Osage County, Oklahoma (Os-35-1); depth, 2,685–2,690 feet. Perthite and plagioclase phenocrysts are set in a devitrified quartz–feldspathic groundmass showing well-defined flow bands. A whole-rock Rb/Sr age of 1,286 ± 24 million years was determined on the sample. Polarized light; field width, 4.2 mm.
4. Metarhyolite porphyry from Porter 20 Miller, 33-23N-3E, Pawnee County, Oklahoma (Pw-7-1); depth, 4,686–4,691 feet. Phenocrysts of perthite and quartz are set in a fine, non-foliated, granoblastic groundmass of quartz–feldspar containing a little chlorite and minor opaque minerals. Plane-polarized light; field width, 0.7 mm.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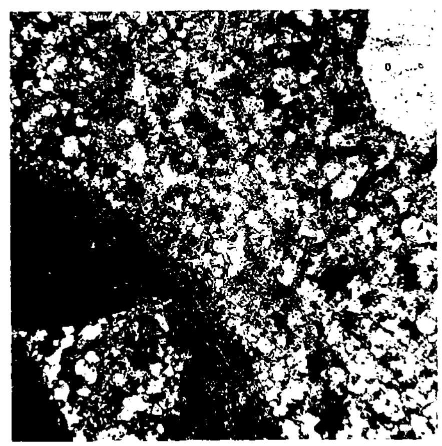
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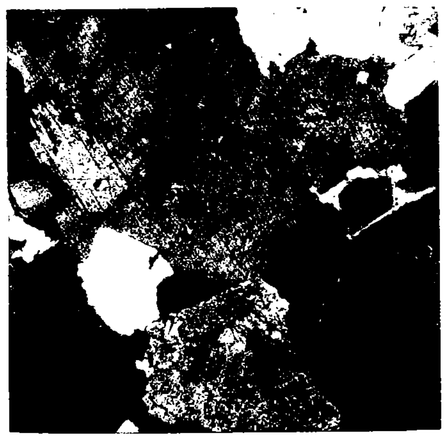
Plate 3—Photomicrographs of Central Oklahoma Granite Group and Osage Microgranite

1. Granite from Pan American 1 Tackett Unit, 28-8N-23E, Le Flore County, Oklahoma (Lf-1-1); depth, 9,270 feet. Large perthite crystal near center is surrounded by partly sericitized plagioclase (lower and right) and quartz (white). Biotite book is seen adjoining perthite in the left center. Perthite from this sample yielded an age of 1,239 ± 52 million years. Rock is typical of Central Oklahoma Granite Group. Polarized light; field width, 4.2 mm.

2. Sheared granite gneiss from Cities Service 5 Farley, 19-11N-2W, Oklahoma County, Oklahoma (Ok-1-1); depth, 8,300–8,310 feet. Relict eye of plagioclase shows rounding by cataclasis. Quartz is extensively lineated and recrystallized. A diabase found in the well shows no cataclastic effects. This is one of two wells from Oklahoma City Field, both of which show shearing. An Rb/Sr determination on feldspar yielded an age of 1,220 ± 73 million years. Polarized light; field width, 0.70 mm.

3. Microgranite porphyry from Texaco 16 Kohpay, 29-25N-8E, Osage County, Oklahoma (Os-27-1); depth, 2,845–2,846 feet. Phenocrysts of quartz and perthite are set in a rather pure quartzofeldspathic groundmass. Groundmass texture is characteristic of Osage Microgranite with spicule-like quartz. An Rb/Sr determination on whole rock yielded an age of 1,183 ± 46 million years. Plane-polarized light; field width, 1.67 mm.

4. Microgranite porphyry from Moore and Ohio 24 Osage, 9-21N-9E, Osage County, Oklahoma (Os-14-1); depth, 2,587–2,592 feet. This shows detail of groundmass texture and somewhat gradational character with some of perthite phenocrysts seen in lower part of photo. Plane-polarized light; field width, 0.70 mm.



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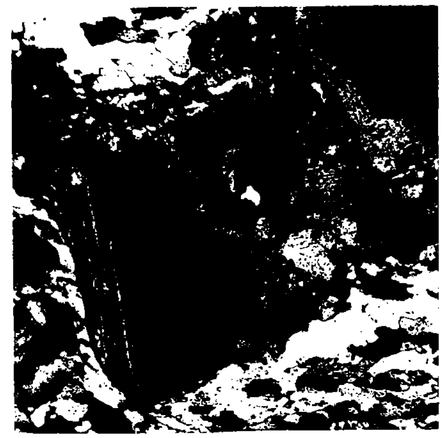

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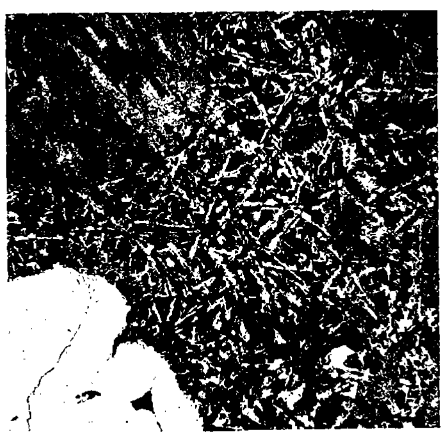

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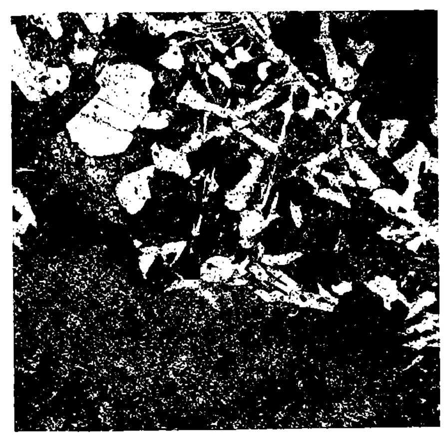

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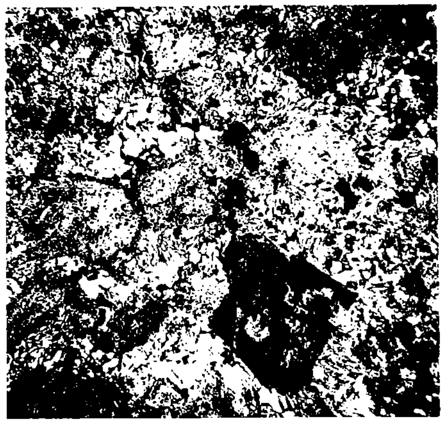
Plate 4—Photomicrographs of Spavinaw Granite Group

1. Micrographic granite porphyry from outcrop near Spavinaw, Oklahoma, 15-22N-21E, Mayes County, Oklahoma. Phenocrysts of plagioclase and perthite are set in delicately micrographic groundmass of quartz–perthite. Iron oxides are common. All original femic minerals have been converted to chlorite. Sample yielded an Rb/Sr age of 1,326 ± 58 million years. Zircons from this outcrop area gave a U/Pb age of 1,370 ± 20 million years. Plane-polarized light; field width, 4.2 mm.

2. Detail of above sample, showing variation in micrographic intergrowth over small area. Plane-polarized light; field width, 1.67 mm.

3. Pyroxene crystals found in micrographic granite from Gulf 1-S Berryhill, 17-17N-12E, Creek County, Oklahoma (Ck-3-1); depth, 3,920–3,929 feet. Although pyroxenes are rare in the Spavinaw granites, they were probably common as original minerals but were converted to chlorite during deuteric alteration. Plane-polarized light; field width, 0.70 mm.

4. Micrographic granite porphyry from Central Commercial 3 Hay, 10-17N-10E, Creek County, Oklahoma (Ck-4-1); depth, 4,205–4,237 feet. This sample is rather typical of the more leucocratic varieties of Spavinaw granites with feldspar phenocrysts set in micrographic quartz–perthite groundmass. An Rb/Sr determination on whole rock yielded an age of 1,212 ± 48 million years. Plane-polarized light; field width, 1.67 mm.



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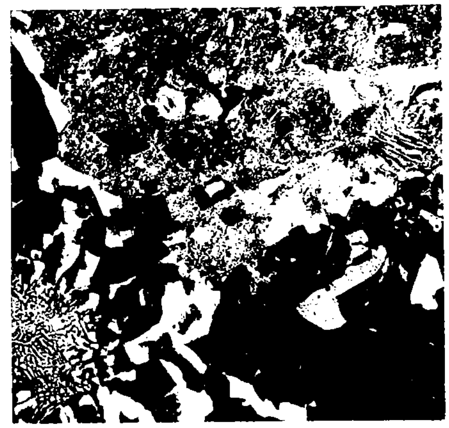

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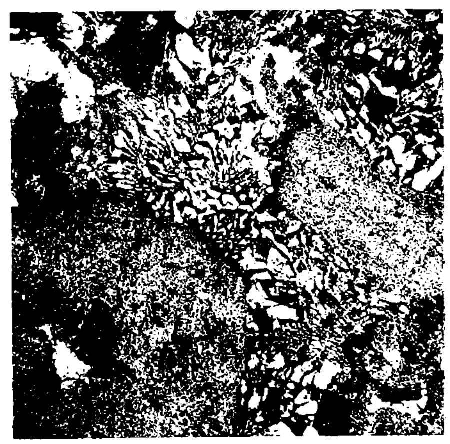

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Binding: Smyth sewn

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Covers: Hardbound on Gane 8117LV red cloth on 160-pt. binder's board
Softbound on 65-lb. Hammermill gray, antique finish