(Upper) Intrusive igneous rocks of the Wichita Mountains, looking westward from the top of Mt. Scott toward Mt. Sheridan (left-center). Granite dated at 525 million years composes most of the hills that can be seen. Gabbro and diorite are in the face of Mt. Sheridan, below the sill of granite that caps it. From a kodachrome transparency by W. E. Ham.

(Lower) Oblique aerial photograph of the East Timbered Hills in the Arbuckle Mountains, looking southward along U. S. Highway 77. Rhyolite supporting the hills has an isotopic age of 525 million years and probably is Middle Cambrian. At upper right are homoclinal Upper Cambrian beds unconformably overlying the rhyolite. Photograph by Dr. F. A. Melton, professor of geology at The University of Oklahoma.

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BASEMENT ROCKS AND STRUCTURAL EVOLUTION OF SOUTHERN OKLAHOMA

by

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CONTENTS

ILLUSTRATIONS

PLATES*

* Plates I-V, which are in the folder accompanying this report, were printed in advance so that a limited number would be available for inclusion in a guidebook of the Ardmore Geological Society, published in October 1963. Hence, the publication date is 1963, as given on the plates.

FIGURES

TABLES

Basement Rocks and Structural Evolution of Southern Oklahoma

William E. Ham, Rodger E. Denison*, and Clifford A. Merritt

ABSTRACT

The investigations for this report were in southern Oklahoma, defined as a region of 17,000 square miles that includes all of south-central and southwestern Oklahoma between the Ouachita Mountains and the Texas Panhandle.

Basement rocks of the region were investigated in outcrops of the Wichita and Arbuckle Mountains and in samples from 178 wells drilled in search for oil and gas. The great depth of basement-rock penetration in some wells is valuable in determining rock sequences, form and contact relations of intrusive bodies, and the change in grade of metamorphism with increasing depth.

Wells establishing probable world records for penetration of granite (11,823 feet) and of gabbro (8,066 feet) have been drilled in southern Oklahoma, and 17 wells of the region have penetrated more than 1,000 feet of basement rocks. Cores and cuttings representing about 83,000 feet of basement rocks have been collected and studied.

About 1,300 thin sections, half from subsurface and half from outcrops, have been examined petrographically. Isotopic age determinations of 13 rocks, selected from critical localities in outcrops and in subsurface, establish useful ages for subdivision and stratigraphic classification. Sixteen new chemical analyses and calculated norms, representing each of the rock groups, also are reported.

Six basement-rock groups, occurring in two provinces, are recognized and mapped in southern Oklahoma. Five groups are related geographically to the Wichita Mountains, and the area of their occurrence is here called the Wichita Province. Three of these groups—Carlton Rhyolite Group, Wichita Granite Group, and Raggedy Mountain Gabbro Group—are exposed in the Wichita Mountains and are mapped over a much greater area in subsurface. Two additional groups—Navajoe Mountain Basalt-Spilite Group and Tillman Metasedimentary Group—have wide subsurface distribution but do not crop out in the region. Previously assigned to the Precambrian, the rocks of the Wichita Province have an isotopic age range of 500 to 550 million years and are now believed to be mostly or entirely of Early and Middle Cambrian age.

The remaining basement rocks are included in the Eastern Arbuckle Province. They are chiefly granites and diorites of deeply eroded batholithic complexes. Dated at 1,050 to 1,350 million years, these rocks are of undoubted Precambrian age and are part of the cratonic

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basement that characterizes large segments of the central United States.

Wichita Province.—The youngest rocks of the Wichita Province are rhyolites and granites dated at 525±25 million years. Consisting mainly of rhyolite flows and tuffs extruded upon a land surface, the Carlton Group represents an extensive volcanic field that is at least 4,500 feet thick. Rocks of the Wichita Granite Group are chiefly perthite leucogranites of various textures emplaced as multiple epizone intrusions, in part having the form of sills 600 to 1,500 feet thick intruding the lower part of the Carlton rhyolite, and in part occurring as irregular plutons and sills cutting all other rocks of the Wichita Province. Wichita granite is the intrusive equivalent of the extrusive Carlton rhyolite. The rhyolites and granites are virtually the same chemically, each having an average silica content of 75 percent.

Next older are rocks of the Navajoe Mountain Basalt-Spilite Group and of the Raggedy Mountain Gabbro Group. The Navajoe Mountain Group consists of basalt, spilite, andesite, and altered palagonite tuff, at least partly of marine deposition, in a subsurface sequence having a drilled thickness of 1,050 feet and a probable total thickness of several thousand feet. It underlies Carlton rhyolite and is intruded by Wichita granite, locally being converted to high-rank hornfels. It is regarded as the extrusive equivalent of the Raggedy Mountain Gabbro Group, the isotopic age of which is about 535 million years. The Raggedy Mountain Group consists of diallage and olivine gabbro, anorthosite, and diorite comprising a layered intrusion possibly 10,000 feet thick, injected as an elongate lens into sandstone and graywacke of the Tillman Metasedimentary Group, the oldest rocks of the Wichita Province.

The Tillman Group consists of meta-graywacke, argillite, quartzite, and bedded chert in a subsurface sequence probably at least 15,000 feet thick, representing marine eugeosynclinal deposits of probable Early Cambrian age. The graywackes are characterized on a regional scale by a recrystallized clay matrix containing relict sand-size clasts of diverse origin. They are converted into hornfels and biotite schist near intrusive contacts with Wichita granite. Quartzite of the Tillman Group occurs as inclusions in gabbro and granite of the Wichita Mountains outcrops.

Eastern Arbuckle Province.—Rocks of the Eastern Arbuckle Province are principally coarse-grained biotite-plagioclase-microcline mesozone granites of a deeply eroded continental craton. Two ages of granite emplacement (1,050 and 1,350 million years) are represented. An intermediate event is recorded by the presence in the subsurface of hornblende diorite, dated at 1,200 million years, which occurs as sills and dikes in the older granite.

Granites of this province are distinguished petrographically, petrologically, and chemically from the Wichita granites. Those from the Eastern Arbuckle Province generally contain at least 20 percent albite-oligoclase; and, with approximately 73 percent silica, 14 percent alumina, and 1.5 percent lime, they are notably lower in silica, and higher in alumina and lime, than the perthite-rich Wichita granites. Petrologically the Eastern Arbuckle Province granites are stamped on a regional scale by the incipient growth of crystalloblastic epidote, muscovite, biotite, and hornblende, whereas such growth normally is absent in the younger granites of the Wichita Province.

Role of basement rocks in structural evolution.—The basement rocks have exerted a profound control over the stratigraphic and structural evolution of southern Oklahoma. During Precambrian time an extensive continental tract was injected by granites and strengthened into a rigid cratonic block. The eastern part of this block has been a stable element from the time of its formation up to the present. After a long period of uplift and deep erosion, it received a relatively thin cover of Paleozoic sediments that have failed structurally by gentle folding and block faulting, as shown by the Tishomingo-Belton-Hunton uplift of the Arbuckle Mountains region. A somewhat similar block is represented in the subsurface by the Muenster arch.

A great intracratonic sag was developed upon the granitic basement floor in all other parts of southern Oklahoma, initiating the Southern Oklahoma geosyncline, which received as much as 60,000 feet of Paleozoic rocks before deposition ended in Permian time. The filling was accomplished in three stages. The earliest stage, heretofore unrecognized, resulted in the accumulation of one-third of the total thickness and was of paramount importance in setting the pattern for subsequent development.

The earliest stage was eugeosynclinal, and its rocks consist of graywacke, bedded chert, spilitic basalt, and rhyolite of the Wichita Province, Early and Middle Cambrian in age, all built up to a probable thickness of 20,000 feet. At this stage the trough was about 100 miles wide and, in Oklahoma, nearly 300 miles long. It doubtless extended much farther southeastward beneath the Ouachita fold belt, perhaps connecting with the Appalachian geosyncline.

A part of the trough margin in southwestern Oklahoma was greatly modified by the injection of gabbro, in the form of a thick concordant lens, followed by the injection of granite, in the form of sills and plutons. These intrusive rocks so consolidated a large portion of the margin that it no longer participated in the geosynclinal sinking but later, through block faulting, became the site of the Wichita Mountains. By the injection of massive igneous rocks a localized stable block was established upon the older continental craton, and, as a result, the locus of later geosynclinal deposition was shifted slightly to the north.

Before the first stage was closed by the widespread extrusion of Carlton rhyolite, major faults originated along opposite margins of the newly modified basin. The basin itself was downthrown as a graben at least one mile. The best information available suggests that these basement-rock faults are coincident with the Meers fault of the Wichita Mountains and with the Washita Valley fault of the Arbuckle Mountains, both of which are major northwestward-trending faults showing enormous movement during Pennsylvanian time. Here is clear implication that the structural grain of Late Paleozoic orogeny in

southern Oklahoma was established during the basement-rock stage of geosynclinal filling.

Included within the region of maximum subsidence of the Southern Oklahoma geosyncline are the Anadarko basin, Marietta basin, Ardmore basin, and, at the western edge of the Arbuckle Mountains, the closely folded Arbuckle anticline. These major geologic units have many similar features. Their underlying basement rocks are those of the Wichita Province; they consist of folds with steeply dipping and locally overturned limbs; and they contain abnormally thick sequences of Paleozoic strata. Sedimentary strata above the basement rocks range in age from Late Cambrian to Permian and range in thickness from 30,000 to 40,000 feet. They represent the two later stages of filling—a miogeosynclinal stage of Upper Cambrian to Devonian carbonate deposition and a final zeugogeosynclinal stage of clastic sedimentation during Carboniferous and Permian time.

In addition to setting a sedimentational pattern of downwarp for the future development of the sinking basin, the basement rocks of the Wichita Province influenced the magnitude and intensity of folding that occurred during the several stages of Pennsylvanian orogeny. The stratiform basement-rock flows are both thick and structurally conformable with the overlying sediments. Therefore they supply a foldable platform instead of an unyielding and rigid base, allowing the formation of closely folded anticlines and synclines. In southern Oklahoma such folding is restricted to those areas that are underlain by foldable rocks of the Wichita Province.

The dominating feature in the development of the Southern Oklahoma geosyncline is the persistence of basinward downwarp throughout a long span of geologic time, during which the geosyncline passed through three distinctive stages without a significant pause in deposition and without premature consolidation. It is probable that the geosyncline is wholly of Paleozoic age, as the youngest sediments are Permian and the oldest deposits—Tillman graywacke—are considered Early Cambrian. The development of this geosyncline was guided by the character and thickness of its basement rocks. First sinking and being filled with thick deposits, and later collapsing by strong folding accompanied by thrust faulting, the geosynclinal segment is markedly different in all its evolutionary aspects from segments underlain by the massive cratonic granites.

INTRODUCTION

The region of southern Oklahoma, as defined for the basement-rock investigations of this report, is a tract about 225 miles long and 65 miles wide, with an area of 470 townships or about 17,000 square miles. It includes all of south-central and southwestern Oklahoma between the Ouachita Mountains and the Texas Panhandle, embracing in its eastern part the strongly folded Paleozoic rocks of the Arbuckle Mountains and, in its western part, the prominent hills of granite and gabbro that are exposed in the deeply eroded core of the Wichita Mountains (fig. 1). Around and between the Arbuckle and Wichita Mountains is a cover of Pennsylvanian and Permian sediments, generally of low dip, and southward from the Arbuckle Mountains are the gently dipping Cretaceous sediments of the Gulf Coastal Plain.

Basement-rock outcrops cover about 400 square miles in the Wichita Mountains and about 150 square miles in the Arbuckle Mountains, for a total of 550 square miles or slightly more than three percent of the entire region. Over considerable parts of the region basement rocks are encountered by drilling at depths less than 5,000 feet, yet the structural contrast is so great that in the deepest basins they probably lie at 30,000 to 40,000 feet—depths so great that the basement is not likely to be penetrated in the foreseeable future.

In the present report we continue the study of surface igneous rocks begun 65 years ago by other workers, and investigate for the first time the samples from numerous wells drilled primarily in a search for oil and gas. Through this combination of surface and subsurface geology, it has been possible to achieve integrated concepts of the basement rocks and to show their relations in a systematic pattern of structural evolution throughout Late Precambrian and Paleozoic time.

The greatest contributions have resulted from the subsurface investigations and from a study of isotopic ages of flows and intrusive rocks, both in outcrops and in subsurface. More than 400 wells have been drilled into basement rocks in 17 counties. This wide coverage has enabled us to map in subsurface the distribution of rock units, which is much different from what had been expected from surface studies, and to discover two important rock groups that

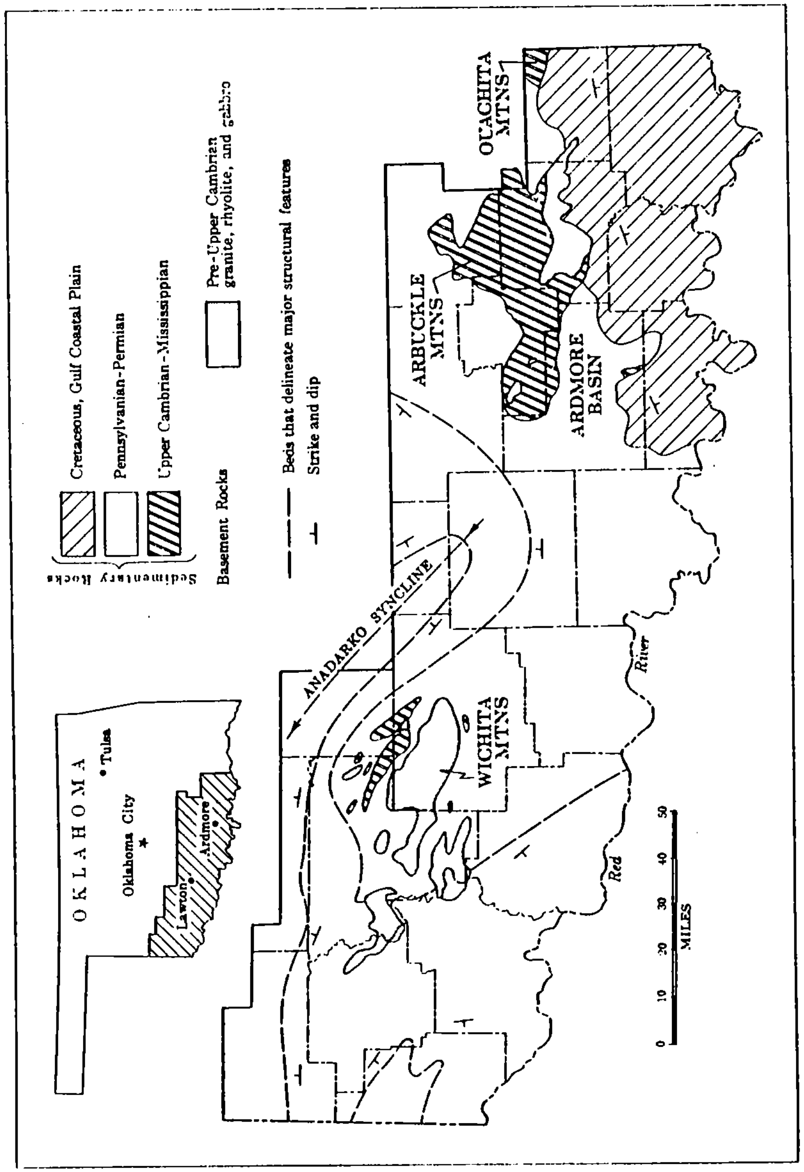

Figure 1. Index map of southern Oklahoma showing major outcrops and structural features.

do not crop out in the Wichita or Arbuckle Mountains. The exceptionally deep penetration of basement rocks—more than 4,000 feet in each of 6 wells and more than 1,000 feet in each of 17 wells—has permitted us to obtain data on thickness and stratiform relations of volcanic flows and to ascertain various intrusive relations, such as the occurrence of sills and the downward passage of meta-graywacke into hornfels. This unusual combination of geologic data, together with the knowledge from outcropping rocks, gives southern Oklahoma the distinction of being one of the most favorable regions for study in the world.

The drilling of numerous wells and the locally thick penetrations of basement rocks are motivated by a search for petroleum in a region that is oil rich and structurally complex. The counties of southern Oklahoma consistently yield per year about 75 million barrels of oil, valued at more than $200 million. Petroleum is produced from formations that range in age from Permian to Late Cambrian and range in depth from 500 to 15,000 feet. The oil-bearing stratigraphic sequence is as much as 40,000 feet thick, and the deepest well of the region is a dry hole drilled to 24,000 feet, abandoned in Mississippian shale. Production is obtained from thin sediments of the shelf environment and from deep basins with complexly overturned folds. Basement rocks have been penetrated in the ordinary course of drilling for oil that occurs under these diverse conditions.

Of greatest importance to basement-rock geology, however, are the high-angle reverse faults that are well known in the Arbuckle and Wichita Mountains and in the area between them. Many wells in southern Oklahoma have been drilled through such faults into productive oil sands. In some wells, such as the Honeymon 1 Townsend in Bryan County and the Frankfort 1 Freeman Heirs in Murray County, thick basement rocks were penetrated before cutting through a reverse fault into Ordovician sedimentary rocks below. Other wells of deep basement-rock penetration, obviously drilled near reverse faults but which failed to cut through into sediments below the faults, include the California 1 Jones, Sinclair 1 Everett Unit, Sohio 1A Kennedy, Shell 1 Galloway, and Carter 1 Emmons.

A final type of basement-rock well in southern Oklahoma has resulted from difficulty in the interpretation of seismic information, which is widely used to discover oil-favorable structures in subsurface. Layered stratiform flows of basement igneous rocks cannot be distinguished satisfactorily in seismic records from layered sedimentary rocks, as was proved by drilling the Stanolind 1 Perdasofpy in Comanche County and the Frankfort 1 Sparks Ranch in Murray County. These wells penetrated thick flows of Carlton rhyolite beneath Reagan (Upper Cambrian) Sandstone and had cut respectively 4,254 and 6,054 feet of basement rocks when drilling was stopped. A similar difficulty in seismic interpretation occurs where sheetlike bodies of diorite and diabase intrude granite, the igneous rocks being block faulted against thick Paleozoic sediments. Location of the Phillips 1 Matoy well in Bryan County evidently was made against this type of geologically complex background, with the resulting penetration of 11,823 feet of Eastern Arbuckle Province basement rocks. So far, it is the deepest basement-rock penetration in southern Oklahoma, and probably is a world record.

PRESENT INVESTIGATIONS

Much of the effort for this report has been concerned with the acquisition, preparation, and evaluation of cores and cuttings of the basement rocks. A preliminary list of 330 wells reportedly drilled into basement rocks in southern Oklahoma, compiled by Merritt and Ham in 1958, was sufficient to show that a rewarding study might be made, if samples could be obtained. Through 1961 a search was made for samples from oil-company offices, private individuals, and well-sample libraries, and a careful check was made of reports on current wells.

The final list contains names and locations of 427 wells, after elimination of those of doubtful wells and those of wells shown by sample examination to be inaccurately reported. Samples from 178 of these wells, distributed within 17 counties, have been obtained and examined (table 1). They constitute the basic subsurface information of the report. Denison, who joined the project in late 1958, has had the responsibility of collecting samples, of making petrographic descriptions of thin sections, and of preparing photomicrographs. His earlier work on subsurface rhyolites and associated rocks in subsurface (Denison, 1958, 1959) was a Master of Science thesis, directed by C. A. Merritt, at The University of Oklahoma.

The total reported penetration of basement rocks in southern Oklahoma is about 110,000 feet. Approximately 83,000 feet has been examined by the writers, of which 60,000 feet is contained in the

TABLE 1.—NUMBER OF WELLS DRILLED INTO BASEMENT ROCKS IN SOUTHERN OKLAHOMA

County	*Number examined for this report*	*Total wells reported*
Atoka	4	6
Beckham	27	55
Bryan	5	9
Carter	1	1
Comanche	13	40
Cotton	6	7
Garvin	4	8
Greer	27	69
Jackson	16	26
Jefferson	8	16
Johnston	5	11
Kiowa	31	115
Murray	4	5
Pontotoc	4	4
Stephens	8	14
Tillman	11	38
Washita	4	4
Total (17 Counties)	178	428

17 wells that penetrated more than 1,000 feet of basement rocks. For this investigation we have studied more than 600 thin sections of samples from subsurface. Wells that penetrated deeply into basement rocks or otherwise have yielded critical information are listed in table 2 (page 18).

All subsurface work has been related as closely as possible to outcrop studies. In the Wichita Mountains these include a long period of investigations by Merritt and his graduate students at The University of Oklahoma (Scull, 1947; Schoonover, 1948; Polk, 1948; Chase, 1950; McKinley, 1950; Walper, 1951; Soule, 1951; Hull, 1951; Green, 1952; Wasteneys, 1962). Manuscript maps by G. W. Chase covering roughly the eastern half of the Wichita Mountains, together with a collection of 450 thin sections, are in the Oklahoma Geological Survey files and have been consulted frequently. Additional mapping by Ham and Denison in the easternmost granite outcrops of the Wichita Mountains near Medicine Park, mapping and stratigraphic measurement of rhyolite flows in the Blue Creek canyon-Bally Mountain area, and mapping by Denison in the southern granite area near Snyder, were used to complete the regional investigations. Approximately 700 thin sections from Wichita Mountains outcrops have been studied.

Granites and rhyolites of the Arbuckle Mountains have been studied briefly in the field by Ham. A collection of some 50 thin sections, including those of Uhl (1932) prepared for a Master of Science thesis at The University of Oklahoma, has been used.

Sixteen new chemical analyses of basement rocks, chiefly from outcrops in the Wichita and Arbuckle Mountains but also in part from subsurface, are included in the report. Norms of these analyses have been calculated by Merritt, who also has determined on the universal stage the An content of plagioclases where modal analyses are given throughout the report.

Much of the essential information is summarized in the form of illustrated logs and maps. Construction of the contour map of the basement-rock surface (pl. II) and the interpretations of regional structure and of the role of basement rocks in the structural evolution of southern Oklahoma have been primarily the responsibility of Ham.

Included in the report is a table of isotopic ages of basement rocks, taken in part from published sources and in part from original data obtained cooperatively with the Crustal Studies Laboratory of The University of Texas.

Previous Investigations

No previous study of the distribution of basement rocks in southern Oklahoma has been published, although a set of geophysical maps (Van Weelden, 1934) provides an important background for certain structural interpretations, and a report by Wideess and Taylor (1959) is of considerable interest in the geophysical interpretation of the basement rocks penetrated in the Stanolind 1 Perdasofpy well in Comanche County. A comprehensive study of basement rocks that includes adjoining parts of Texas (Flawn, 1956) is valuable as a framework against which the southern Oklahoma rocks can be compared, and a recent report on the same area by Wasserburg and others (1962) gives useful isotopic ages.

Outcrops of igneous rocks in the Wichita and Arbuckle Mountains have been described in numerous reports, particularly those of Bain (1900), Taff (1904), Taylor (1915), Hoffman (1930), Hamilton (1956), and Merritt (1958). A large-scale map of gabbroic rocks

in the central part of the Wichita Mountains was published by Chase (1950b). Special features of the gabbroic rocks have been described by Huang and Merritt (1952, 1954) and by Huang (1955). A major project on the basic igneous rocks of the Wichita Mountains is in progress by Hunter (1962), under whose direction Master of Science theses at The University of Oklahoma were completed by Gilbert (1960), Hiss (1960), Johnson (1960), Rotan (1960), Karns (1961), Spencer (1961), and Frech (1962). In addition to the previously listed Master of Science theses completed under the direction of Merritt at The University of Oklahoma, Smith (1951) described the igneous rocks of the Snyder Lake area as a Master of Science thesis at the University of Tulsa.

Radioactive age dating of basement rocks in Oklahoma began with alpha counting of zircon from granite in the Wichita Mountains (Larsen and others, 1953). Workers at the Carnegie Institution of Washington began a program of isotopic age determinations of igneous rocks of southern Oklahoma in 1957 (Davis and others), culminating in a comprehensive report by Tilton and others, published in 1962, in which the earlier work is summarized.

Acknowledgments

To many individuals and companies we owe a debt of gratitude for giving or lending subsurface samples of the basement rocks. Although virtually every oil company in Oklahoma has participated, thanks for special effort and interest are due the Shell Oil Company, Magnolia (Socony Mobil) Petroleum Company, Amerada Petroleum Corporation, Stanolind (Pan American) Oil Company, Columbian Fuel Corporation, Frankfort Oil Company, Sinclair Oil & Gas Company, California Oil Company, Atlantic Refining Company, Mack Oil Company, and Shamrock Oil Company.

Samples have been obtained mainly from Shell Oil Company, Magnolia Petroleum Company, Amerada Petroleum Corporation, Columbian Fuel Corporation, The University of Oklahoma Sample Library, and the Ardmore Sample Library. Special thanks are due J. Elbert King of the Ardmore Sample Library for supplying samples without charge, for our purposes of scientific research.

The Stanolind Oil Company lent thin sections from the Perdasofpy well in Comanche County, and Lawrence Muir lent thin sections of samples from the Champlin 1 Hieber in Washita County.

Table 2.—Important Basement-Rock Wells in Southern Oklahoma

Province	Well name	Location. County	Basement rock penetrated, feet	Remarks
Eastern Arbuckle Province	Phillips 1 Matoy	24-5S-11E Bryan	11.823	Maximum penetration of Eastern Arbuckle Province rocks and maximum penetration of basement rocks in southern Oklahoma. Abundant diorite injects granite. Diorite isotopically dated.
Eastern Arbuckle Province	California 1 Jones	9-7S-10E Bryan	3.835	Thick penetration of granite cut by diabase.
Eastern Arbuckle Province	Honeymon 1 Townsend	30-5S-8E Bryan	3.653	Thick penetration of granite cut by exceptionally abundant sills and dikes of diabase. Basement rock is faulted over Ordovician strata on the south side of the Tishomingo anticline.
Eastern Arbuckle Province	Sinclair 1 Everett Unit	1-7S-9E Bryan	2.190	Thick penetration of granite.
Eastern Arbuckle Province	Sinclair 1 Peterson	32-6S-6W Jefferson	783	Isotopic age of 1,050 m.y. on feldspar shows this granite to be youngest rock of Eastern Arbuckle Province.
Eastern Arbuckle Province	Fain-Porter 1 Peters	34-2S-8E Johnston	750	Drilled through granite into Ordovician sediments on the north side of the Belton anticline. Granite shows marked incipient metamorphic effects.
Wichita Province	Phillips 1 Martin	27-9N-23W Beckham	2.986±	Maximum penetration of Wichita granite.
Wichita Province	Jordan 1 Caudill Estate	27-9N-25W Beckham	1.711	Thick penetration of Wichita granite.
Wichita Province	Gulf 1 Day	12-8N-22W Beckham	1.043	Thick penetration of Wichita granite.
Wichita Province	Gulf 1 Back	34-9N-22W Beckham	1.033	Thick penetration of Wichita granite.
Wichita Province	Frankfort 1 Sparks Ranch	32-1S-1W Murray	6.054	Thick penetration of Carlton rhyolite and underlying Wichita granite. Maximum penetration of Carlton Rhyolite Group (4,525 feet).
Wichita Province	Sohio 1A Kennedy	26-1N-2W Garvin	4.393	Thick penetration of Carlton rhyolite and underlying Wichita granite.
Wichita Province	Shell 1 Galloway	21-8N-18W Washita	4.367	Maximum penetration of Carlton rhyolite in Wichita Mountains region.
Wichita Province	Carter 1 Emmons	25-2N-9W Stephens	1.310	Thick penetration of Carlton rhyolite. Isotopic age of rhyolite core.
Wichita Province	Frankfort 1 Freeman Heirs	1-1S-1W Murray	1.000	Thick penetration of Carlton rhyolite, which is faulted over Ordovician strata.
Wichita Province	Stanolind 1 Perdasofpy	11-4N-12W Comanche	4.254	Penetration of Carlton Rhyolite Group and underlying Navajoe Mountain Basalt-Spilite Group, with a 600-foot-thick sill of Wichita granite between them. Maximum penetration of Navajoe Mountain Group (1,049 feet), and best knowledge of spilites and palagonite tuff in this group.
Wichita Province	Carter 1 Williford	24-2N-9W Stephens	1.639	Thick penetration of Carlton Rhyolite Group and Navajoe Mountain Basalt-Spilite Group.
Wichita Province	McCasland-Wilcox 1 Edwards	9-3N-21W Jackson	819	Thick penetration of andesite in Navajoe Mountain Group.
Wichita Province	Champlin 1 Hieber	30-8N-20W Washita	8.066	Maximum penetration of Raggedy Mountain Gabbro Group. Sequence consists of gabbro, anorthosite. and troctolite.
Wichita Province	Barnes 1 Gamble	7-8N-26W Beckham	875	Maximum penetration of diorite in Raggedy Mountain Group. Isotopic date on diorite.
Wichita Province	Mid American 1 Briscoe	28-8N-22W Beckham	1.019	Thick penetration of Raggedy Mountain Group.
Wichita Province	Wadley et al. 1 Capps	10-1N-18W Tillman	325	Maximum penetration of meta-graywacke in Tillman Metasedimentary Group.
Wichita Province	Mid Continent 1 Perry	30-1S-16W Tillman	257	Meta-graywacke of Tillman Group grades down into hornfels, resulting from intrusion of Wichita granite.
Wichita Province	Shaffer 1 Howard	9-2N-19W Jackson	69	Best samples of bedded chert in Tillman Group.

The cost of analyzing six outcrop samples by the University of Minnesota Rock Analysis Laboratory was defrayed by a grant in 1958 to Merritt from The University of Oklahoma Alumni Development Fund. Five additional analyses of basement rocks were made by John Schleicher in the Geochemical Laboratory of the Oklahoma Geological Survey.

In working informally with two separate programs of isotopic dating of the basement rocks, we acknowledge with thanks the friendly cooperation of George Tilton and George Wetherill for work performed at the Carnegie Institution of Washington, and of William Muehlberger, director of the Crustal Studies Laboratory at The University of Texas, for making possible five additional determinations by the Isotope Geology Branch of the U. S. Geological Survey. The work of the Crustal Studies Laboratory is supported by Contract AF49(638)-1115 of the Air Force Office of Scientific Research as a part of the Advanced Research Agency Project VELA UNIFORM.

The painstaking drafting of maps, sections, and text-figures for this report has been done by Roy Davis, Marion Clark, and Eileen Krall of the Oklahoma Geological Survey.

TIME CLASSIFICATION OF THE ROCK GROUPS AND PROVINCES

General Classification

The several basement rocks of southern Oklahoma are divided into mappable groups and provinces. These are listed in table 3, along with the best available information and interpretation on isotopic and stratigraphic ages. Five rock groups are related geographically to the Wichita Mountains of southwestern Oklahoma, and the area of their occurrence is here called the Wichita Province. They are the Carlton Rhyolite Group, Wichita Granite Group, Navajoe Mountain Basalt-Spilite Group, Raggedy Mountain Gabbro Group, and Tillman Metasedimentary Group. Three of these groups— Carlton Rhyolite, Wichita Granite, and Raggedy Mountain Gabbro—are exposed in the Wichita Mountains and are mapped over a much greater area in subsurface. The others—Navajoe Mountain Basalt-Spilite and Tillman Metasedimentary—have wide subsurface distribution but do not crop out in the region. Previously assigned to the Precambrian, the rocks of the Wichita Province are now believed to be mostly or entirely of Cambrian age.

The remaining basement rocks occur in the Eastern Arbuckle Province. They are chiefly microcline-bearing biotite granites of a deeply eroded batholithic complex. Widely distributed in the eastern area of the southern Oklahoma region, these rocks are of undoubted Precambrian age and are part of the cratonic basement that characterizes large segments of the central United States.

Before the advent of radioisotope age dating, all basement rocks of southern Oklahoma were considered to be of Precambrian age. An unconformity, upon which basal conglomerates are normally present, was known to separate the succession of Upper Cambrian sedimentary rocks from the underlying basement rocks. The time value of this unconformity was unknown but was believed to be of considerable magnitude, in view of the supposition that most of the basement rocks were granites which had been emplaced at depth and which could not have been exposed by Late Cambrian time except through great uplift and deep erosion. This relationship is now known to be true only for that part of southern Oklahoma in

TABLE 3.—BASEMENT-ROCK GROUPS AND PROVINCES IN SOUTHERN OKLAHOMA

	Stratigraphic age	Isotopic age (million years)		
	LATE CAMBRIAN		Reagan Sandstone, Honey Creek Limestone, and lower part of Arbuckle Group. Stratigraphically dated by trilobites. Strata of each unit lie unconformably upon an uneven floor of basement rocks, locally consisting of every rock group except Raggedy Mountain Gabbro.	
			·····unconformity·····	
Younger Basement Rocks (Wichita Province)			EXTRUSIVE AND METASEDIMENTARY ROCKS	INTRUSIVE ROCKS
	MIDDLE CAMBRIAN (?)	525±25	*Carlton Rhyolite Group* Mainly rhyolite flows and tuffs extruded upon a land surface, forming an extensive volcanic field at least 4,500 feet thick, representing the last stage of basement-rock filling of the Southern Oklahoma geosyncline. Extrusive equivalent of the Wichita Granite Group. Dated by four isotopic age determinations.	*Wichita Granite Group* Chiefly perthite leucogranites of various textures representing multiple intrusions, in part having the form of extensive sills 600 to 1,500 feet thick intruding the lower part of the Carlton Rhyolite Group, and in part occurring as irregular plutons and sills cutting all other rocks of the Wichita Province. Dated by four isotopic age determinations.
			·····probable unconformity·····	
	EARLY CAMBRIAN (?)	535±30	*Navajoe Mountain Basalt-Spilite Group* Basalt, spilite, andesite, and altered palagonite tuff, a least partly of marine origin, in a subsurface sequence having a drilled thickness of 1,050 feet and a probable total thickness of several thousand feet. Underlies Carlton rhyolites and is intruded by Wichita granites. Probable extrusive equivalent of Raggedy Mountain Gabbro Group. No isotopic age determinations.	*Raggedy Mountain Gabbro Group* Diallage and olivine gabbro, anorthosite, and diorite comprising a layered intrusion possibly 10,000 feet thick, injected as an elongate lens into rocks of the Tillman Metasedimentary Group, and probably the chief stabilizing element in the horst-like evolution of the Wichita Mountains. Extensively cut by Wichita granites. Dated by two isotopic age determinations.
	LATE PRECAMBRIAN OR EARLY CAMBRIAN	>550	*Tillman Metasedimentary Group* Low-rank meta-graywacke, argillite, quartzite, and bedded chert in subsurface sequence probably at least 15,000 feet thick, representing marine eugeosynclinal deposits in the first stage of filling of the Southern Oklahoma geosyncline. Graywackes are converted into hornfels and biotite schist near intrusive contacts with Wichita granites. No isotopic age determinations.	
			·····major unconformity·····	
Older Basement Rocks	PRECAMBRIAN	1,100 1,350		*Eastern Arbuckle Province* Principally coarse-grained biotite-plagioclase-microcline granites of a deeply eroded continental craton. Two ages of granite intrusion (1,050 m.y. and 1,350 m.y.) are represented. An intermediate event is recorded by hornblende diorite, dated at 1,200 m.y., which occurs in subsurface as sills in the older granite.

which Upper Cambrian sediments rest upon granites of the Eastern Arbuckle Province. The largest outcrop where this contact can be examined is in the Mill Creek-Ravia area of Johnston County (Ham, 1949), although the same relations may be seen at five other outcrop localities in the eastern part of the Arbuckle Mountains region (Ham and McKinley, 1954).

At all other outcrops in the Arbuckle Mountains and Wichita Mountains, where a basal contact of Upper Cambrian strata is exposed, the underlying basement rock is rhyolite. Generally only slightly altered and still retaining flow lines as well as euhedral phenocrysts of feldspar and quartz, the rhyolite was presumed to have escaped the metamorphism of Early and Middle Precambrian time, and therefore probably was Late Precambrian.

Isotopic Ages

The extent of geologic knowledge was greatly enlarged by the advent of radioactive age measurements. The first work of this type in Oklahoma was that of Larsen and others (1953), who used the lead-alpha method to determine an age of approximately 640 million years on large zircon crystals from a pegmatite in the Quanah granite, in the Wichita Mountains. Another application of the same method was made on zircon concentrated from the Tishomingo granite in the Arbuckle Mountains, the analyses yielding a calculated age of approximately 940 million years (Gottfried and Waring, *in* Hamilton, 1956, p. 1328). Both zircons have since been dated by isotopic analyses, which show that the earlier Quanah age determination was approximately 20 percent too high, whereas the Tishomingo age was about 35 percent too low. The order of absolute age magnitude, however, was first established by the simple method of alpha counting, and the granites of southern Oklahoma were given more confidently a Precambrian age.

An understanding of the complex basement-rock history of the region has been greatly strengthened by the recent work at the Carnegie Institution of Washington, both in the Geophysical Laboratory and in the Department of Terrestrial Magnetism. The first reliably determined ages of Oklahoma rocks were reported by the Carnegie Institution in 1957 (Davis and others, 1957, p. 170). Isotopic determination of U^{238}/Pb^{206}, U^{235}/Pb^{207}, Pb^{207}/Pb^{206}, and Th^{232}/Pb^{208} in the Quanah zircon, and of Rb^{87}/Sr^{87} and K^{40}/A^{40} in biotite from a granite in the same region, gave ages that range from 500 to 550 million years. G. R. Tilton and G. W. Wetherill of the Carnegie Institution visited the writers and accompanied them to igneous-rock outcrops in the Arbuckle and Wichita Mountains in May 1957, at which time additional collections were made. Published results of the analyses of these samples are given in table 4, taken mainly from the 1962 report by Tilton and others.

Analyses at the Carnegie Institution of Washington now have yielded age determinations of four different granites that crop out in the Wichita Mountains, as well as of one gabbro and one rhyolite from outcrops in the Wichita Mountains and of one granite from outcrops in the Arbuckle Mountains. An additional analysis of a core of diorite from Bryan County is available from the work of M. N. Bass at the Carnegie Institution.

The four analyses of Wichita granites are particularly significant because the ages of these rocks, calculated from five different pairs of mother-daughter isotopes in zircon, feldspar, and biotite, are concordant within 10 percent. The Wichita granites clearly have an absolute age of approximately 525±25 million years, and the time of their emplacement, which can be ascertained from field relations as pre-Upper Cambrian, is now available as a well-documented date in the geologic time scale.

Isotopic ages of the remaining basement-rock groups in southern Oklahoma were less precisely established from studies by the Carnegie Institution, owing mainly to the small number of samples investigated.

Beginning in 1962 and continuing through early 1963, however, a cooperative program of age dating was established between the Oklahoma Geological Survey and the Crustal Studies Laboratory of The University of Texas, under the direction of William R. Muehlberger. The Crustal Studies Laboratory is investigating basement rocks in North America, the research program being supported by Contract AF49(638)-1115 of the Air Force Office of Scientific Research as part of the Advanced Research Agency Project VELA UNIFORM. Under this program the Crustal Studies Laboratory entered into a cooperative agreement with the Isotope Geology Branch of the U. S. Geological Survey to date rock groups in the buried basement of North America. The age work is done under the supervision of S. S. Goldich, Branch Chief.

TABLE 4.—ISOTOPIC AGES OF BASEMENT ROCKS IN SOUTHERN OKLAHOMA

(See explanation, pages 28-29)

Province and Group	Rock	Material dated	Calculated Age (million years) $\frac{U^{238}}{Pb^{206}}$	$\frac{U^{235}}{Pb^{207}}$	$\frac{Pb^{207}}{Pb^{206}}$	$\frac{Th^{232}}{Pb^{208}}$	$\frac{Rb^{87}}{Sr^{87}}$	$\frac{K^{40}}{A^{40}}$	Probable age (m. y.)
Wichita Province — Wichita Granite Group	1. Lugert granite[2] Lake Altus Greer County	Biotite					500[a] 475[b]	480	525±25
	2. Lugert granite[1] Camelback Mtn. Kiowa County	Feldspar					520[a] 495[b]		
	3. Headquarters granite[2] Granite Greer County	Feldspar					520±30[a] 495±30[b]		
	4. Pegmatite cutting[2] Quanah granite Comanche County	Zircon	A 520 B 515	525 520	550±30 550±20	505 495			
Wichita Province — Carlton Rhyolite Group	5. Massive rhyolite[1] Bally Mountain Kiowa County	Zircon	505	485	400±200	400±40			525±25
	6. Rhyolite core[2] Carter 1 Emmons Stephens County	Whole rock					535±90[a] 510±90[b]		
	7. Colbert porphyry[2] East Timbered Hills Murray County	Whole rock					505±60[a] 480±60[b]		
	8. Colbert porphyry[2] West Timbered Hills Murray County	Whole rock					495±120[a] 470±120[b]		
Wichita Province — Raggedy Mountain Gabbro Group	9. Gabbro[1] Meers Post Office Comanche County	Biotite					535±30[a] 515±30[b]	510	535±30
	10. Diorite[2] Barnes 1 Gamble Beckham County	Biotite						500	
Eastern Arbuckle Province	11. Tishomingo granite[2] Ten Acre Rock Johnston County	Biotite Zircon	 970	 1080	 1320±70	 1200	1350[a] 1280[b]	1250	1.100 1.350
	12. Diorite[1] Phillips 1 Matoy Bryan County	Biotite					1185[a,3] 1120[b]		
	13. Granite core[2] Sinclair 1 Peterson Jefferson County	Feldspar					1110[a] 1050[b]		

[1] Analysis by Carnegie Institution of Washington. Analytical data published elsewhere.
[2] Analysis by U. S. Geological Survey. Analytical data listed in table 5, this report.
[3] Analytical data not published.
[a] Age calculated from decay value of 1.39×10^{-11}/year. It was determined geologically by Aldrich, Wetherill, Tilton, and Davis (1956) and is preferred by Carnegie Institution of Washington.
[b] Age calculated from decay value of 1.47×10^{-11}/year. It was determined by liquid scintillation counting by Flynn and Glendenin (1959) and is preferred by the U. S. Geological Survey.

As a result of this new program, five ages were obtained on basement rocks in critically located outcrops and wells in southern Oklahoma. The samples include one rhyolite, one diorite, and one granite from subsurface cores and cuttings, and two rhyolites from outcrops in the western part of the Arbuckle Mountains. Without exception these ages confirmed the validity of the rock groups as recognized and mapped during earlier phases of the southern Oklahoma project.

The thirteen investigated samples (table 4) permit reasonably accurate age assignments to three rock groups of the Wichita Pro-

Explanation for Table 4

1. Medium-grained pink Lugert leucogranite in type area near town of Lugert, at Quartz Mountain on west shore of Lake Altus, from fresh road cut leading to Quartz Mountain Lodge, NE¼ SE¼ SW¼ sec. 15, T. 5 N., R. 20 W., Greer County, Oklahoma. For location and regional geology see Merritt, 1958, plate I. Chemical analysis, norm, and mode are given in table 18, this report. Sample was taken within one-half mile of contact along which Lugert granite intrudes Reformatory granite. Isotopic analyses by Tilton and Wetherill, *in* Davis and others, 1957, p. 170.

2. Medium-grained pink Lugert leucogranite, quarry of Century Granite Company, Camelback Mountain, NW¼ SW¼ sec. 20, T. 5 N., R. 18 W., Kiowa County, Oklahoma. The feldspar is microcline-perthite. Tilton and others, 1962, table 1. For location and regional geology see Merritt, 1958, plate I.

3. Fine-grained pink Headquarters leucogranite, quarry three miles northwest of Granite, SW¼ SW¼ SW¼ sec. 9, T. 6 N., R. 21 W., Greer County, Oklahoma. The feldspar is orthoclase-perthite. Tilton and others, 1962, table 1. For location and regional geology see Merritt, 1958, plate I.

4. Crystals of deep-brown zircon as much as one inch in diameter, from abandoned prospect pit in zircon-quartz-feldspar pegmatite dike that cuts coarse-grained Quanah granite, C NE¼ sec. 21, T. 3 N., R. 15 W., northwest slope of Charons Mountain Garden, Wichita Mountains Wildlife Refuge, Comanche County, Oklahoma. Analyses by Tilton, *in* Davis and others, 1957, page 170, slightly modified in Tilton and others, 1962, table 1. Zircons A and B are separate zones separated from a single large crystal, A having uranium and thorium contents about six times those of B.

5. Flow of massive rhyolite porphyry, southwest face of Bally Mountain, SW¼ SW¼ SW¼ sec. 27, T. 6 N., R. 14 W., Kiowa County, Oklahoma. Flow is represented by beds 5-11 of Bally Mountain measured section, figure 4 of this report. Chemical analysis, norm, and mode of the rock are given in table 18, this report. Zircon concentrate prepared by Oklahoma Geological Survey; isotopic analysis by G. R. Tilton, *in* Tilton and others, 1962, table 1.

Several problems were encountered in making the zircon concentrate and in making the isotopic determinations. First, zircon from the rhyolite is intimately intergrown with magnetite and contains inclusions of it, so that a magnetite-free concentrate could not be obtained. Second, the zircon contains only 197 ppm uranium, which is one-fifth the concentration in the usual granite zircon. Finally, there is more common lead in the high-magnetic fraction of the zircon concentrates than in the low-magnetic fraction. Analyses given in the table are determinations in which the U, Th, and Pb concentration data were obtained on the low-magnetic fraction, and Pb isotopic composition on the high-magnetic fraction. This resulted in a loss of accuracy and what must be considered an unsatisfactory Pb^{207}/Pb^{206} age. New attempts to make low-magnetic zircon failed, and no further isotopic work was done. The conclusion of Dr. Tilton and the present writers is that the U^{238}/Pb^{206} age is reliable and that the Carlton zircon has the same age as the Quanah zircon.

6. Rhyolite containing 15 percent perthite phenocrysts, core from depth of 7,227-7,229 feet, Carter Oil Co. 1 Emmons well, SE¼ NE¼ sec. 25, T. 2 N., R. 9 W.,

vince and show a moderate range in age of the several rocks of the Eastern Arbuckle Province. Four determinations of rocks in the Wichita Granite Group agree, within limits of experimental error, with four determinations of rhyolites in the Carlton Rhyolite Group, at an age of 525±25 million years. The rocks of each group are petrographically similar, and it had been previously determined from field relations that the hypabyssal granites were probable age equivalents of the extrusive rhyolites, both having been derived from a common magma. Gabbro and diorite of the Raggedy Mountain Gabbro Group, believed from field relations to be older than the

Stephens County. Chemical analysis, norm, and mode of this rock are given in table 18, this report. Isotopic analysis made in the Washington laboratory of the U. S. Geological Survey under the supervision of S. S. Goldich, with the collaboration of the Crustal Studies Laboratory of The University of Texas.

7. Red rhyolite porphyry, top of East Timbered Hills in the Arbuckle Mountains, NE¼ sec. 1, T. 2 S., R. 1 E., Murray County. Chemical analysis, norm, and mode of this rock are given in table 18, this report. Isotopic analysis made in the Washington laboratory of the U. S. Geological Survey under the supervision of S. S. Goldich, with the collaboration of the Crustal Studies Laboratory of The University of Texas.

8. Rhyolite porphyry associated (interlayered?) with volcanic breccia or agglomerate, West Timbered Hills in the Arbuckle Mountains, C NE¼ SE¼ NE¼ sec. 10, T. 1 S., R. 1 W., Murray County. Isotopic analysis made in the Washington laboratory of the U. S. Geological Survey under the supervision of S. S. Goldich, with the collaboration of the Crustal Studies Laboratory of The University of Texas.

9. Coarse-grained biotite-diallage gabbro from valley of Medicine Creek, one mile south of Meers Post Office, SE¼ SE¼ sec. 32, T. 4 N., R. 13 W., Comanche County. Sample collected by Oklahoma Geological Survey, about 75 feet from large inclusion of Meers Quartzite, in area where gabbro is cut by numerous dikelets of granite. Isotopic analysis by Wetherill, *in* Tilton and others, 1962, table 1.

10. Medium-grained biotite-hornblende-pyroxene diorite, cuttings from depth of 3,230-3,400 feet, Earl Barnes 1 Gamble well, C NW¼ NE¼ sec. 7, T. 8 N., R. 26 W., Beckham County. Biotite occurs in well-defined books of euhedral crystals which were hand picked from the cuttings, yielding a biotite sample that weighed 1.30 grams. Isotopic analysis made in the Washington laboratory of the U. S. Geological Survey under the supervision of S. S. Goldich, with the collaboration of the Crustal Studies Laboratory of The University of Texas.

11. Coarse-grained biotite-granite porphyry from abandoned Capitol Quarry at Ten Acre Rock, C NE¼ sec. 3, T. 3 S., R. 5 E., Johnston County. Chemical analysis, norm, and mode of the rock are given in table 18, this report. Isotopic determinations by Tilton and Wetherill, *in* Tilton and others, 1962, table 1. Biotite and zircon were concentrated from same rock.

12. Hornblende-rich diorite from the Phillips 1 Matoy well, C SW¼ NW¼ sec. 24, T. 5 S., R. 11 E., Bryan County. Core from a 50-foot sill of diorite in Tishomingo granite at a depth of 1,001 feet and 300 feet below drilled top of granite (pl. III, this report). Isotopic determinations by M. N. Bass, Carnegie Institution of Washington, personal communication and letter of June 30, 1961. A point-count modal analysis of a thin section of the same core, loaned by Dr. Bass, gave hornblende 55%, plagioclase and its alteration products 20%, biotite 21%, opaque minerals 2%, and accessory minerals 2%. The biotite is reddish brown and mostly unaltered.

13. Coarse-grained pink biotite granite, core from depth of 4,663-4,666 feet, Sinclair Oil and Gas 1 Peterson well, NW¼ SW¼ NE¼ sec. 32, T. 6 S., R. 6 W., Jefferson County. The dominant feldspar is microcline perthite. Isotopic analysis made in the Washington laboratory of the U. S. Geological Survey under the supervision of S. S. Goldich, with the collaboration of the Crustal Studies Laboratory of The University of Texas.

TABLE 5.—ANALYTICAL ISOTOPIC AGE-DATA
(Samples 6, 7, 8, 10, and 13 of table 4)

Sample	Type	Rb (ppm)	Rb^{87} (ppm)	SrN (ppm)	tSr^{87}/Sr^{86}	$*Sr^{87}$ (ppm)	Age (m.y.)
6. Carlton rhyolite Carter 1 Emmons 25-2N-9W Stephens County	total rock	102	28.7	104	0.7243	0.214	510±90
7. Colbert porphyry East Timbered Hills 1-2S-1E Murray County	total rock	113	32.1	56.4	0.7447	0.228	480±60
8. Colbert porphyry West Timbered Hills 10-1S-1W Murray County	total rock	146	41.4	176	0.7198	0.287	470±120
13. Granite Sinclair 1 Peterson 32-6S-6W Jefferson County	feldspar	229	64.7	74.1	0.8438	1.011	1,050±60
			K_2O (%)	K^{40} (ppm)	$*Ar^{40}$ (ppm)	Ar^{40} (%)	
10. Diorite Barnes 1 Gamble 7-8N-26W Beckham County	biotite		8.82	8.93	0.298	97	500

* Radiogenic
SrN=normal strontium (excludes $*Sr^{87}$)
tSr^{87}=total strontium-87

Constants: Rb^{87}, $\lambda_\beta = 1.47 \times 10^{-11}$/year
$Rb^{87} = 0.283$
K^{40}, $\lambda_e = 0.585 \times 10^{-10}$/year
$\lambda_\beta = 4.72 \times 10^{-10}$/year
$K^{40} = 1.22$ gm/gmK

geographically allied Wichita granites and Carlton rhyolite, are assigned an age of 535±30 million years. Biotite from Raggedy Mountain gabbro at Meers post office (table 4, no. 9) yielded the oldest Rb^{87}/Sr^{87} date and the oldest K^{40}/A^{40} date of any investigated rock in the Wichita Province, the values being 15 to 35 million years older than those of the associated granites. The isotopic ages thus confirm the field observations that the oldest intrusives of the Wichita Province are those of the Raggedy Mountain Gabbro Group.

Finally, three age determinations of rocks assigned to the Eastern Arbuckle Province indicate a time span of granite intrusion at least from 1,100 to 1,350 million years, and possibly as much as 1,050 to 1,400 million years. A diorite of intermediate age (about 1,200 million years) intrudes the older granite. All the rocks assigned to this province are of Precambrian age, and they are separated by an erosional unconformity of great magnitude from the rocks of the Wichita Province.

STRATIGRAPHIC AGES

When the isotopic age of the Quanah granite was isotopically and concordantly determined to be approximately 525 million years, opinion was expressed in the United States and abroad that the Wichita Mountains of southwestern Oklahoma had supplied a definitive point in the geological time scale. The Quanah granite was presumed to lie unconformably under Cambrian sedimentary rocks, therefore permitting the conclusions that the granite was Precambrian and that the beginning of Cambrian time was approximately 500 million years ago. These conclusions doubtless were prompted by the fact that the earlier time scale of Holmes (1947) had placed the Cambrian-Precambrian boundary at 520 million years. Such close correspondence suggested that the proposed date had been in fact confirmed in the field, whereas in truth the field relations do not support this conclusion.

Because the southern Oklahoma region has become controversially involved in this geologically important problem, at times leading to the expression of factual inaccuracies, the critical points of present knowledge are here briefly reviewed.

First of all, no rocks dated by fossils as Early or Middle Cambrian have been found in southern Oklahoma, and none has been reported from the continental interior of the United States. It is also probable that great difficulty will be encountered in finding such fossiliferous deposits, for they would be deeply buried beneath younger rocks and could be studied only in cores and cuttings. That these rocks will be extensively cored is unlikely, and it is even less likely that datable fossils will be found in the cores. Accordingly, southern Oklahoma is part of a vast region in which the base of the Cambrian System cannot be faunally defined, and it is therefore clear that the definition of the line of separation between Cambrian and Precambrian must be based upon models in other areas.

The one point established beyond question is that in southern Oklahoma the basement rocks are older than Late Cambrian. A widely distributed and locally thick sequence of Upper Cambrian sedimentary rocks covered all parts of the region, and, except where removed in areas of strong Pennsylvanian uplift and erosion (pl. II), the sequence is still preserved. Normally at the base of the sequence is the Reagan Sandstone, as much as 450 feet thick. It is overlain by Honey Creek Limestone, generally 100 to 200 feet thick, and this is succeeded upward by limestones of the Arbuckle Group. Total maximum thickness of the Upper Cambrian beds is about 1,800 feet. Their assignment to Late Cambrian time is made principally from trilobites in the Honey Creek and Arbuckle limestones. The oldest trilobites, including the genera *Elvinia, Camaraspis,* and *Taenicephalus,* occur in the Honey Creek Limestone. They have been studied by Frederickson (1949) and are assigned unquestionably to the Franconian (middle Late Cambrian) stage. The underlying Reagan Sandstone is mostly unfossiliferous, but it is regarded from its transitional contact to be a gradational phase of the Honey Creek Limestone and, therefore, to be of early Franconian or late Dresbachian age (Howell and others, 1944, chart 1).

Where the base of the Upper Cambrian succession is exposed, the Upper Cambrian strata above the unconformity contain pebbles and cobbles of the underlying basement rock. The unconformable surface itself is locally quite irregular, and in one outcrop area of the Arbuckle Mountains the total relief along the unconformity is known to be 950 feet (Ham, 1949, p. 47). Here the Reagan Sandstone is overlapped, and strata of the Honey Creek Limestone and Arbuckle Group come progressively to rest upon the sides and over the tops of buried granite hills. Similar, though much lesser, relief is known in the Blue Creek canyon area of the Wichita Mountains,

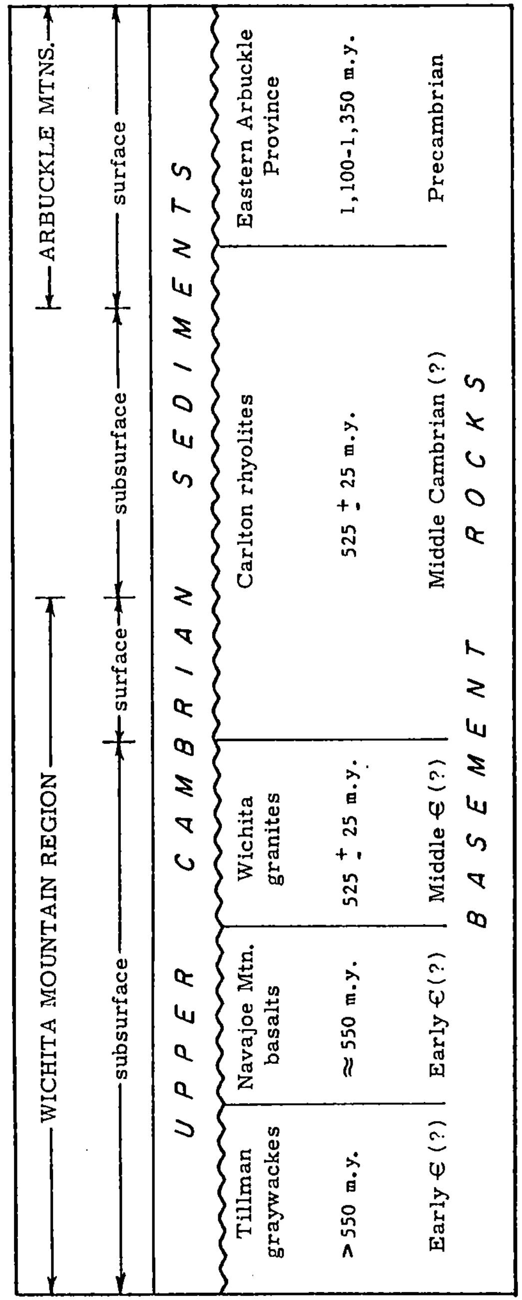

Figure 2. Schematic summary of stratigraphic relations of Upper Cambrian sediments to basement-rock groups in southern Oklahoma.

where Honey Creek Limestone locally overlaps Reagan Sandstone and rests unconformably upon rhyolite. From a regional viewpoint, however, the unconformity is a nearly smooth surface of low relief. Finally, the work done for the present investigation supports the conclusions of earlier workers that no igneous rock in southern Oklahoma, surface or subsurface, is intrusive into the Reagan Sandstone, and all are pre-Late Cambrian in age.

Five of the six basement-rock assemblages in southern Oklahoma lie unconformably beneath Upper Cambrian beds (fig. 2). The contact relations with only two of these assemblages are known from outcrops in the Arbuckle and Wichita Mountains, the remaining three being known from subsurface studies in the Wichita Mountains region. As shown in the map and sections of plate I, Carlton rhyolite is the basement rock that underlies Upper Cambrian strata over the greatest area in southern Oklahoma. From outcrops at the eastern edge of the Wichita Mountains, this area extends over a broad subsurface belt to outcrops in the western part of the Arbuckle Mountains. Here the time value of the unconformity is at a minimum, for rocks of the Carlton Group are the youngest of the basement complex, and they consist of extrusive flows and tuffs that generally are structurally conformable with the Upper Cambrian beds. The only physical changes indicated are the dying out of volcanic activity and the inundation of the eroded volcanic land surface to receive the marine deposits of Late Cambrian time.

In all parts of southern Oklahoma outside the elongate rhyolite belt, the time value of the pre-Upper Cambrian unconformity is greater, because in all other areas pronounced uplift and erosion occurred before deposition of the Reagan Sandstone. In the southern part of the Wichita Mountains region the uplift was so pronounced that rhyolite flows were eroded away, and Upper Cambrian strata came to rest successively upon Wichita granites, Navajoe Mountain basalts, and Tillman metasediments. These relations are clearly shown by subsurface mapping. At no place, however, was erosion sufficiently deep to expose gabbro at this unconformable surface.

The unconformity has its greatest time value in those areas where Reagan Sandstone is underlain by granites and diorites of the Eastern Arbuckle Province. Dated at 1,100 to 1,350 million years, these rocks are of Late Precambrian age and had been deeply eroded through a long period of uplift preceding Reagan time.

Probable Cambrian Age of Basement Rocks of the Wichita Province

One of the more perplexing problems of the entire investigation is concerned with the stratigraphic age of rocks in the Wichita Province. Where should these rocks be placed within the geologic time scale? Are they Precambrian, as considered in the past? Are these rocks dominantly intrusive granites and gabbros, as can be seen so plainly in outcrops of the Wichita Mountains? Or does the assemblage consist in large measure of flows and sediments, as can be shown by subsurface studies?

The best information now available strongly suggests that the intrusive rocks are concentrated within the linear Wichita Mountains belt of pronounced uplift, whereas the flows and sediments dominate an adjoining linear belt of even greater geosynclinal subsidence. The geosynclinal belt, here called the Southern Oklahoma geosyncline, coincides approximately with the principal mapped area of Carlton rhyolite, where the value of the pre-Upper Cambrian unconformity is known to be at a minimum. Deep drilling and seismic information on the margin of the geosyncline show a pre-Upper Cambrian sequence of stratified and stratiform rocks approximately 20,000 feet thick. This sequence is succeeded upward, without appreciable structural discontinuity, by 35,000 to 40,000 feet of Early, Middle, and Late Paleozoic sedimentary rocks (fig. 3). An evolutionary pattern of three depositional stages is apparent. The first or basement-rock stage, built up by a filling of graywackes and volcanic flows, was followed by an Upper Cambrian-Devonian stage dominated by carbonate rocks, whereas the third and closing stage was a Mississippian-Permian filling by clastic sediments.

We can see no structural reason for separating the basement rocks of the Wichita Province from the sediments of known Paleozoic age that overlie them in the geosyncline. The entire succession is a three-stage filling, approximately 60,000 feet thick, resulting from long-continued and persistent downwarp of a single geosynclinal tract. In many essential respects this geosyncline bears the stamp of Appalachian evolution and may, in fact, be an arm of that province projected from the southeast into the Oklahoma region.

The rocks of the Appalachian geosyncline include those of Early and Middle Cambrian age, and the same age is considered probable for the earliest rocks of the Southern Oklahoma geosyncline.

A second philosophical consideration helps to confirm the opinion that rocks of the Wichita Province are Cambrian. The newly proposed time scales of Holmes (1959)[1], Polevaya (1960), and Kulp (1961), place the beginning of Cambrian time at approximately 600 million years. Two of the Oklahoma rock groups—Carlton Rhyolite and Wichita Granite—are dated at 525±25 million years. If the 600-million-year date is accepted for the beginning of

[1] For a discussion of the age of the Cambrian, see Wetherill (1960) and Holmes (1960).

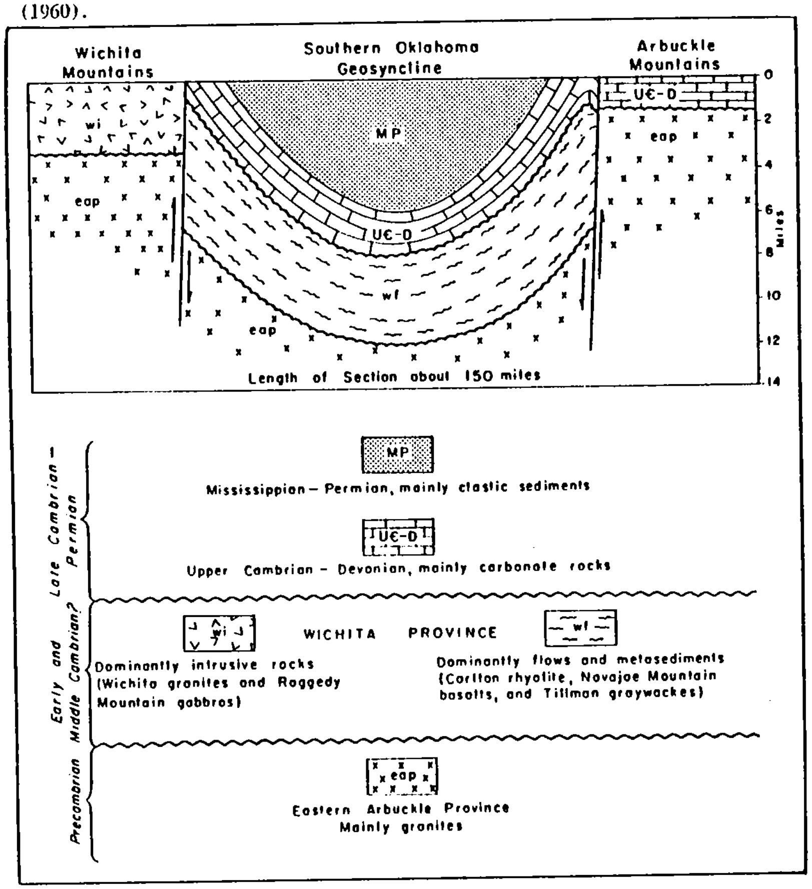

Figure 3. Schematic diagram of the Southern Oklahoma geosyncline and its relation to intrusive rocks of the Arbuckle and Wichita Moutains.

the Cambrian, it follows that the granites and rhyolites must be at least as young as Middle Cambrian. For this reason we assign them a Middle Cambrian (?) age.

The three lower divisions of the Wichita Province are the Tillman Metasedimentary Group, Navajoe Mountain Basalt-Spilite Group, and Raggedy Mountain Gabbro Group. The gabbro has been dated at 535±30 million years, and the basalts, spilitic flows, and tuffs of the Navajoe Mountain Group, although not isotopically dated, are considered to be the extrusive equivalents of the Raggedy Mountain Gabbro Group. Both groups probably are of Early Cambrian age.

Undated are the meta-graywackes of the Tillman Metasedimentary Group. They underlie the Navajoe Mountain flows and tuffs and, together with them, constitute a typical graywacke-spilite-bedded chert assemblage of normal eugeosynclinal deposits. As the two groups almost certainly are petrologic associates in the thick early stage of filling of the Southern Oklahoma geosyncline, it follows that they probably are related in time of formation and therefore probably share an Early Cambrian age. Even with the strong petrologic association, however, the length of time required for deposition of the graywackes is so indefinite that the age of the Tillman metasediments may in part be Late Precambrian.

THE WICHITA PROVINCE

Carlton Rhyolite Group

INTRODUCTION

The largest outcrop area of rhyolite in Oklahoma is in a low range of hills near Lawton, at the eastern edge of the Wichita Mountains. The smoothly rounded treeless hills of rhyolite are easily separable from the rough-weathering hills of nearby granite, and the term Carlton Mountains was in current use for this topographic feature when the first major geological report on the region was made (Taff, 1904, pl. II). Taff correctly mapped the 15 square miles of rhyolite outcrop and informally called it the Carlton Mountain porphyry. In slightly earlier usage Bain (1900, p. 135-137) had called it Carrollton Mountain porphyry, and in a later paper Hoffman (1930, p. 39-48) called it the Carlton granophyre; but in more recent years all workers in the Wichita Mountains have used the term Carlton rhyolite, and this usage is adopted for the present report.

The term Carlton Mountains is no longer in use. All the rhyolite area formerly included under Carlton Mountains is now a part of the Fort Sill Military Reservation, wherein most hills are individually named. Examples are Jones Ridge, Signal Mountain, and Medicine Bluffs. One of these rhyolite hills, the peak of which is in the northern part of sec. 1, T. 2 N., R. 13 W., is now called Carlton Mountain. This hill is not to be considered the type locality of the group, however, as the original users of the term Carlton clearly intended it to apply to all rhyolites of the Lawton area.

Taff (1904, pls. I, II) also correctly mapped two more areas of rhyolitic rocks in the Wichita Mountains and two in the Arbuckle Mountains, about 75 miles to the east. These are the Blue Creek canyon area and the Bally Mountain-Zodletone area north of Lawton, and the West Timbered Hills and East Timbered Hills of the Arbuckle Mountains. With this mapping Taff, in 1904, had discovered all the outcropping rhyolite of southern Oklahoma, and he indicated (p. 64) that certain types of rhyolite from the Carlton Mountain area were the same as those in Blue Creek canyon and in the East Timbered Hills.

The investigations for the present paper both confirm and extend the conclusions of Taff. As here used, the term Carlton Rhyolite Group includes all rhyolitic rocks in the Wichita Mountains and Arbuckle Mountains[1], and their equivalents in subsurface, which underlie at least 7,000 square miles of southern Oklahoma. The rocks are dated stratigraphically as pre-Upper Cambrian and have an absolute age of 525±25 million years. Their probable age assignment is Middle Cambrian. Most of the rocks are part of an enormous volcanic field, locally at least 4,500 feet thick, and are made up chiefly of rhyolitic flows, water-laid tuff, agglomerate, and welded tuff. The type locality is here chosen as Bally Mountain, on the north flank of the Wichita Mountains, where a sequence of stratiform flows and tuffs, 3,600 feet thick, has been measured.

Extrusion of the volcanic rocks was contemporaneous with the crystallization of Wichita granites at shallow depth. The period of formation of this extrusive-intrusive series was long continued, and at many localities the early phases of rhyolite, principally the basal part of the Carlton Group, are extensively injected by granite and are locally altered or converted into hornfels. The reverse age relation, that of granite injected by intrusive rhyolite, also is known at a few localities.

Together with the closely related Wichita granites, the Carlton Rhyolite Group is the youngest basement rock in southern Oklahoma. In all parts of the deeply down-folded Southern Oklahoma geosyncline it lies unconformably but with slight discordance beneath the Reagan Sandstone, closing the volcanic early stage of geosynclinal evolution.

DISTRIBUTION

Rhyolitic lavas and pyroclastic strata of the Carlton Group are the most widely distributed basement rocks known in southern Oklahoma. Within the mapped area (pl. I) they extend principally as a broad northwestward-trending belt that lies between the Wichita Mountains and the granites of the Eastern Arbuckle Province. This belt coincides approximately with the configuration of the Southern Oklahoma geosyncline, made up of elements of the Anadarko basin, Ardmore basin, and Marietta basin (pl. II). Along the uplifted mar-

[1] The rhyolites of the East Timbered Hills and West Timbered Hills of the Arbuckle Mountains, called Colbert porphyry by Reeds (1910, p. 31-32), are coextensive in subsurface with the Carlton rhyolite and are here considered a part of that group.

gins are the rhyolite outcrop areas of the East and West Timbered Hills in western Murray County, at the eastern edge of the basinal downwarp, and of the Lawton-Blue Creek canyon-Bally Mountain-Zodletone areas at the western edge. The volcanic sequence has a maximum drilled thickness of 4,500 feet in the Frankfort Sparks well in western Murray County and an exposed thickness of 3,600 feet at Bally Mountain in northeastern Kiowa County. Thirty-nine wells have been drilled into Carlton rhyolite within the area of the geosynclinal belt, mostly along the margins and along a medial axis of uplift. The greatest depth at which the top of the rhyolite has been drilled is 12,620 feet, in the Jones 3 Wallace-Reed well, sec. 6, T. 5 S., R. 1 W., in south-central Carter County.

Rocks of the Carlton Rhyolite Group probably extend in subsurface along the Anadarko basin into the northeastern part of the Texas Panhandle (pl. V). This principal segment is about 300 miles long and 50 miles wide, and has an area of 15,000 square miles. The presence of two outliers, one in western Greer County and the other on the Altus dome in east-central Jackson County, indicates that the original areal extent was at least 17,000 square miles. A volcanic field of such great extent, composed almost exclusively of rhyolitic flows and associated pyroclastic rocks, must have had numerous widely distributed feeders.

The eastern margin of Carlton rhyolite in south-central Oklahoma is believed to coincide with a pre-rhyolite fault, cutting granites of the Eastern Arbuckle Province. Southwest of the mapped contact the rhyolite is at least 4,500 feet thick, as shown by drilling, whereas northeast of the contact rhyolite is unknown (section B-B′, pl. I). As here interpreted, the volcanic field was terminated against the escarpment of an upthrown block. The block served as a wall that contained the flows within the basin, the height of the wall evidently being maintained by recurrent uplift along faults (pl. IV, A-4).

Everywhere in outcrops of the Wichita and Arbuckle Mountains the Carlton Group consists of rhyolite flows, tuffs, and agglomerates. These pyroclastic rocks, which are particularly valuable in demonstrating the extrusive origin of rocks of the group, are well exposed at Bally Mountain and Zodletone Mountain in the Wichita Mountains, and in the West Timbered Hills at the western edge of the Arbuckle Mountains.

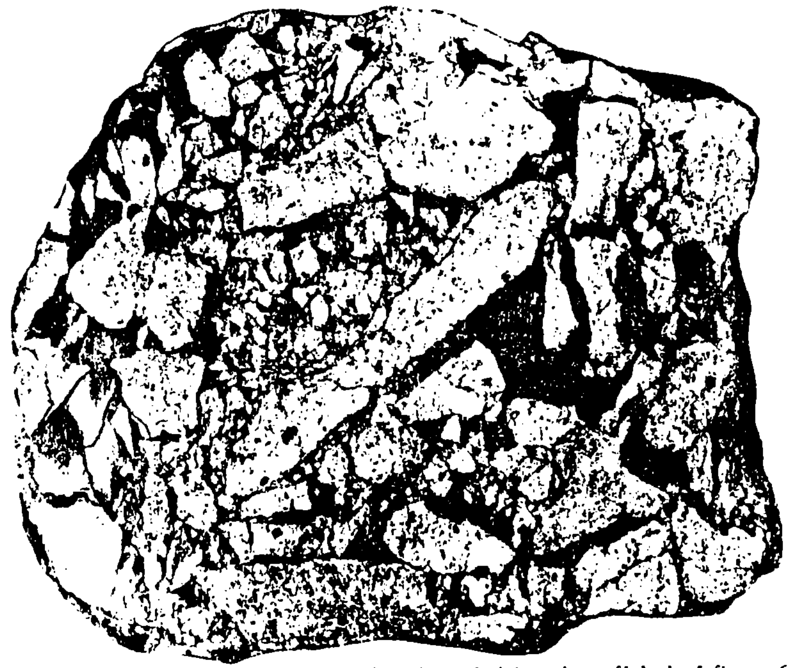

Figure 5. Rhyolite agglomerate, x1, directly underlying the tuff bed of figure 6. Angular fragments of spherulitic rhyolite are enclosed in a dark matrix of devitrified shards and dust. Upper part of bed 3 of Bally Mountain measured section.

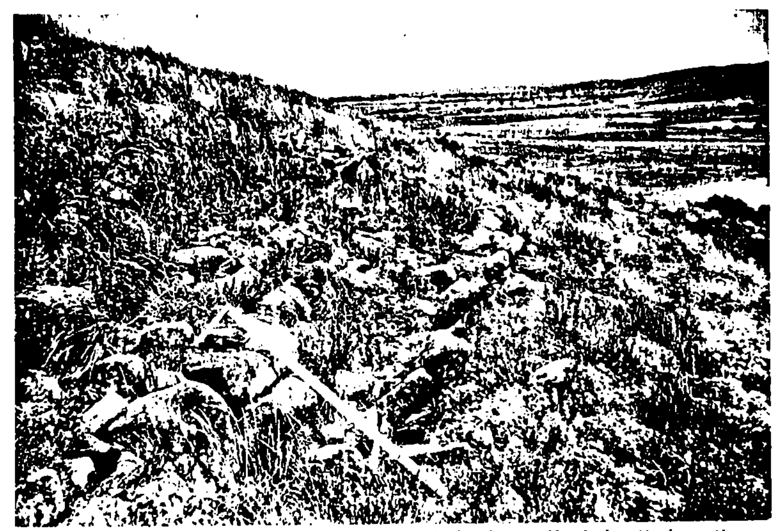

Figure 6. Outcropping beds of well-stratified rhyolite tuff of the Carlton Group, southwest face of Bally Mountain (bed 4), SW¼ SW¼ SW¼ sec. 27, T. 6 N., R. 14 W. At this locality the tuff is 24 feet thick and dips uniformly to the left at an angle of 40°. Jacobs staff is 5 feet long. For photomicrograph of thin section, see plate VIII-6.

TYPE LOCALITY

Probably the best outcrops of the Carlton Rhyolite Group are at Bally Mountain, on the northeast flank of the Wichita Mountains in northeastern Kiowa County. The locality is easily accessible by county roads and is mapped on the U. S. G. S. Bally Mountain 7½-minute topographic sheet. Bally Mountain is in SW¼ sec. 27, T. 6 N., R. 14 W., but outlying related hills of well-exposed rhyolite continue eastward and occur directly below the Upper Cambrian succession of Reagan Sandstone, Honey Creek Limestone, and Fort Sill Limestone. Within this area a homoclinal sequence of rhyolite flows and tuffs nearly 3,600 feet thick can confidently be measured,

Figure 7. Thinly sheeted and flow-banded rhyolite porphyry of Carlton Group, bed 17 of Bally Mountain measured section, NE¼ SW¼ SE¼ sec. 27, T. 6 N., R. 14 W. The weathered beds resemble thinly stratified sedimentary rocks.

using the concordant flow lines of lava beds and bedding planes of water-laid tuff to establish dip and strike. One complete chemical analysis, a determination of isotopic age from zircon in the rhyolite, and numerous thin sections are available to assist in interpretation, and the Bally Mountain area is here designated as the type locality of the Carlton Rhyolite Group. The measured section of the type section of the group is given in table 6.

(text continues on page 46)

Table 6.—Measured Section of Carlton Rhyolite Group Bally Mountain Section

S½ S½ sec. 27, N½ N½ sec. 34, and NW¼ SW¼ sec. 26, T. 6 N., R. 14 W., Kiowa County, Oklahoma

Measured July 7-8, 1959, by W. E. Ham and R. E. Denison

Reagan Sandstone

Coarse-grained gray and reddish-brown unfossiliferous sandstone containing cobbles and boulders of rhyolite porphyry at base. Grades upward into Honey Creek Formation, which contains Upper Cambrian (Franconian) trilobites. Strike N. 32° W., dip 50° NE. at base and 45° NE. at top.

— — — — unconformable base of Upper Cambrian strata — — — —

	Carlton Rhyolite Group (3,597 feet measured)	Thickness (feet)
26.	Rhyolite porphyry, reddish-brown; in part flow-banded and highly fractured. Strike N. 35° W., dip 41° NE. on flow banding	255
25.	Rhyolite porphyry, orange-red; weathers into well-separated parallel layers	17
24.	Single bed of completely flow-banded rhyolite (pl. VI, pl. VII-1, pl. VIII-1) containing euhedral feldspar phenocrysts ¼ to ½ inch long. Strike N. 45° W., dip 35° NE.	3.5
23.	Orange-red rhyolite porphyry, in part finely flow-banded and in part contorted on a major scale around irregular masses of nearly black rhyolite that contains bright-pink feldspar phenocrysts. A thin section shows the rock to be a welded tuff, partly silicified, composed of devitrified subparallel shards (pl. VIII-5)	85
22.	Single bed of strikingly flow-banded rhyolite. Flow bands are ½ to 1 inch thick, remarkably parallel, and are weathered in various shades of brown. Flesh-	

pink feldspar phenocrysts are locally prominent; quartz phenocrysts rare 4.5

21. Rhyolite porphyry with definite but crudely defined flow and fluxion structure. Rocks are closely jointed. Reddish-brown groundmass encloses rounded to euhedral phenocrysts of pink feldspar. In thin section phenocrysts are seen to be strongly corroded and groundmass to be coarsely devitrified. Strike consistently N. 45° W., dip 38° NE. 250

20. Covered by slope debris and soil from base of hill in NW¼ SW¼ SW¼ sec. 26 to low hill on west side of creek near center SE¼ SE¼ sec. 27 700

19. Rhyolite porphyry, massive to shattered, on low hill 90

18. Covered by thick soil 85

17. Thinly sheeted and flow-banded rhyolite porphyry, many layers of which weather like thin-bedded sandstones (fig. 7). Pink feldspar phenocrysts locally make up one-third of rock and are as much as one-half inch in diameter. Interlayered beds are of normal brownish rhyolite containing well-scattered orange-red feldspar phenocrysts. A thin section shows strongly corroded perthite phenocrysts, some surrounded by spherulitic coronas. The rock is probably a series of thin flows rather than welded tuff. Strike N. 35° W., dip 40° NE. 170

16. Massive to spheroidal rhyolite porphyry, probably a blocky flow. Groundmass locally silicified; vugs, some 10 inches in diameter, are filled with milky quartz or lined with euhedral drusy quartz. In thin section perlitic cracks are seen as relicts in devitrified groundmass 37

15. Massive rhyolite porphyry weathering into polygonally jointed blocks, interpreted as a massive flow or sill. Caps hill 110

14. Covered by thick soil on well-defined bench which slopes concordantly with regional dip of flows. Probably a deeply weathered diabase sill 17

13. Well-jointed rhyolite porphyry, showing little or no preferred orientation of phenocrysts or other flow fabric. In thin section: strongly corroded clusters and single crystals of perthite, plagioclase, and rare quartz are embedded in coarsely devitrified groundmass 182

12. Rhyolite porphyry, in part prominently layered and flow-

banded. Quartz and feldspar phenocrysts abundant. Strike N. 35° W., dip 41° NE. 395

11. Massive rhyolite porphyry weathering into polygonal joint blocks with surfaces. Flow fabric lacking. Forms crest and east slope of Bally Mountain. In thin section: reddish-brown coarsely devitrified spherulitic groundmass encloses strongly corroded phenocrysts of perthite, plagioclase, and quartz (pl. VIII-3). Chemical analysis (M-2) and isotopic age determinations of zircon made on rhyolite from this unit 515

10. Covered bench on scarp face of Bally Mountain, probably a weathered diabase sill 30

9. Massive rhyolite, strongly sheeted and jointed 38

8. Covered bench, probably diabase or basalt 5

7. Massive rhyolite, same as on crest of Bally Mountain 140

6. Covered bench, probably diabase or basalt 30

5. Massive closely jointed rhyolite 17

4. Rhyolitic tuff, dark reddish-brown, well-bedded interstratified medium- to fine-grained layers (fig. 6). Beds mostly 1 to 2 feet thick, weathering smooth and rounded. In thin section: grains are subangular fragments, chiefly of perthite, devitrified spherulitic glass, and magnetite (pl. VIII-6). Strike N. 30° W., dip 40° NE. 24

3. Rhyolite porphyry grading into flow breccia and agglomerate (fig. 5). Rhyolite blocks are as much as 6 inches in diameter, rounded to angular. Entire sequence crops out as a single massive rough-weathering ledge, practically unjointed, low in the scarp face of Bally Mountain. In thin section: fragments are mainly spherulitic rhyolite embedded in devitrified vitroclastic matrix 262

2. Covered on grassy slope 30

1. Rhyolite porphyry, closely jointed and weathered into flagstone slabs that strike N. 30° W. and dip 40° NE. Dark reddish-brown groundmass contains pink feldspar and colorless quartz phenocrysts. At base of southwest face of Bally Mountain, SE¼ NW¼ NW¼ NW¼ sec. 34, T. 6 N., R. 14 W. 105

Base of section covered by Permian red shales.

Measured thickness of Carlton Rhyolite Group.... 3,597

ISOTOPIC AND STRATIGRAPHIC AGE

Rocks assigned to the Carlton Rhyolite Group have been considered by all previous workers to be Precambrian in age. At each of the five outcrop areas the rhyolitic rocks are unconformably overlain by the Reagan Sandstone, and at one locality of the Blue Creek canyon area (Frederickson, 1948, p. 1351-1352) they are overlain by Honey Creek Limestone. Reagan Sandstone is the overlying rock in every deep well drilled to rhyolite in the basinal part of southern Oklahoma, and this is the normal sequence for the region, except at a few localities where the rhyolite floor was unevenly eroded and Reagan Sandstone was overlapped by Honey Creek Limestone upon the sides of a rhyolite hill.

The Honey Creek Limestone is known from its trilobite fauna to be Franconian or middle Late Cambrian in age (Frederickson, 1949); and the Reagan Sandstone, although mostly unfossiliferous, is regarded as a gradational phase of the Honey Creek and therefore to be of early Franconian or possibly late Dresbachian age (Howell and others, 1944, chart 1). The oldest sedimentary rock that rests upon the rhyolite is unquestionably Upper Cambrian, and the rhyolite itself, which everywhere occurs as cobbles or pebbles in the basal conglomerate of the directly overlying sediments, is definitely pre-Late Cambrian in age.

Isotopic ages determined from four samples of rhyolite are about 525 million years (table 4), essentially the same as the age of the Wichita granites. One of the analyzed samples is from Bally Mountain in the Wichita Mountains, one is from a subsurface core in Stephens County, and two are from outcrops in the western part of the Arbuckle Mountains.

The three most recently proposed time scales of Holmes (1959), Polevaya (1960), and Kulp (1961) place the Cambrian-Ordovician boundary at 465 to 500 million years and the beginning of Cambrian time at approximately 600 million years. Unfortunately, the base of the Cambrian is the most weakly established point in each of the three scales, for there is general disagreement concerning this boundary in the field, as well as the additional difficulty of finding suitable material for age dating within or associated with the rocks concerned. The solution to the problem must await more detailed investigation in areas where fossiliferous Early Cambrian rocks are known. Although the solution will not be found in southern Oklahoma, the regional framework of this area as discussed on later pages, together with the general conclusions arrived at by Holmes, Polevaya, and Kulp, strongly suggests to the present writers that the Carlton rhyolite is Middle Cambrian in age.

RELATIVE AGES

Closely associated with the Carlton Group are rocks of the Wichita Granite Group. Each has an isotopic age of about 525 million years, and thus it is established that the extrusive rhyolites are the time equivalents of the intrusive granites. Together they are the youngest basement rocks in southern Oklahoma. Extrusion of rhyolite as a series of discontinuous flows and tuffs, intermittently ejected to build up a vast and thick volcanic field, was accompanied at depth by the intermittent intrusion of granite. Thus, although contemporaneously formed during the same magmatic epoch, they are nevertheless partly overlapping in time of origin. Just as the early rocks of the rhyolite sequence are injected by granite sills, so are the early-formed granites cut by feeders of late-stage rhyolite. One of the best exposures of Carlton rhyolite cutting a granite of the Wichita Group is in the north road cut of State Highway 49 just east of Medicine Creek, SW¼ NW¼ NW¼ sec. 20, T. 3 N., R. 12 W.

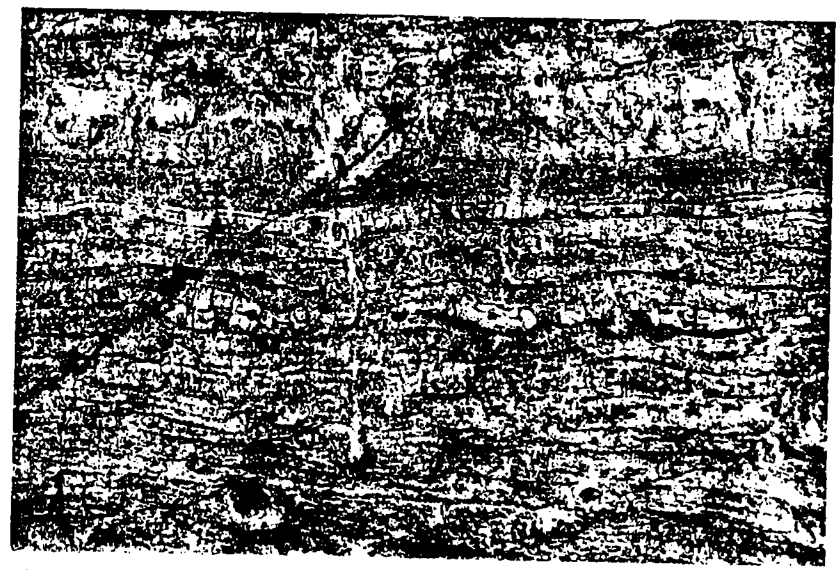

Figure 8. Weathered surface of hornfelsic Carlton rhyolite, x1.1, south shore of Lake Elmer Thomas, SW¼ NE¼ NW¼ sec. 24, T. 3 N., R. 13 W. Well-developed flow banding is preserved. Layers and subparallel lenses of high relief are rich in quartz. For thin section photomicrographs, see plate IX-1, 2.

From present knowledge, however, it is apparent that the most common occurrence of Wichita granite in southern Oklahoma is as sill-like bodies injected at or near the base of the rhyolite series. At a few localities the intrusive relation is shown by the moderate alteration of rhyolite at a granite contact or by the occurrence of rhyolite inclusions in granite.

The best outcrop region in which these relations can be studied is in the Fort Sill Military Reservation. Here the form of the Carlton outcrop, together with dips and strikes of flow bands within it, as mapped by Schoonover (1948), suggests that the rhyolite is folded into an eastward-plunging syncline (fig. 9). Granite is in contact with rhyolite on the north and southwest limbs, and apparently underlies the entire rhyolite body. In one area just south and west of Lake Elmer Thomas, NE¼ sec. 23 and NW¼ sec. 24, T. 3 N., R. 13 W., the contact relations can be studied. At least 60 feet of altered rock lies below normal Carlton rhyolite and above a Wichita granite. The lower part of the altered rock sequence is massive and has been extensively changed by silicification and sericitization (fig. 8; pl. IX, 1-4); the degree of alteration diminishes upward and at the top is weakly silicified rhyolite containing phenocrysts of quartz and partly sericitized feldspar. The contact with overlying flow-banded Carlton rhyolite is irregular. Hoffman (1930, p. 39) called the rock Davidson granophyre, but our interpretation from field relations and petrographic examination is that the altered zone represents Carlton rhyolite, which is hydrothermally altered and partly converted to hornfels by intrusion of granite. The most altered beds are possibly hornfelsic tuffs.

Three deep penetrations of rhyolite by wells in southern Oklahoma confirm the injection of Wichita granite into the lower part of the Carlton Group. In the Stanolind 1 Perdasofpy well, a granite sill 600 feet thick is intruded between Carlton rhyolite and the Navajoe Mountain Basalt-Spilite Group; and in the Frankfort 1 Sparks well, granite is injected at the base of Carlton rhyolite that has a drilled thickness of 4,500 feet (pl. III). The same relations are found in the Sohio 1A Kennedy, NW¼ NW¼ SE¼ sec. 26, T. 1 N., R. 2 W.

Numerous xenoliths of banded rhyolite hornfels occur in hills of Wichita granite just east of Snyder, mostly in S½ SW¼ sec. 7 and NE¼ sec. 18, T. 2 N., R. 16 W., at the southern edge of the

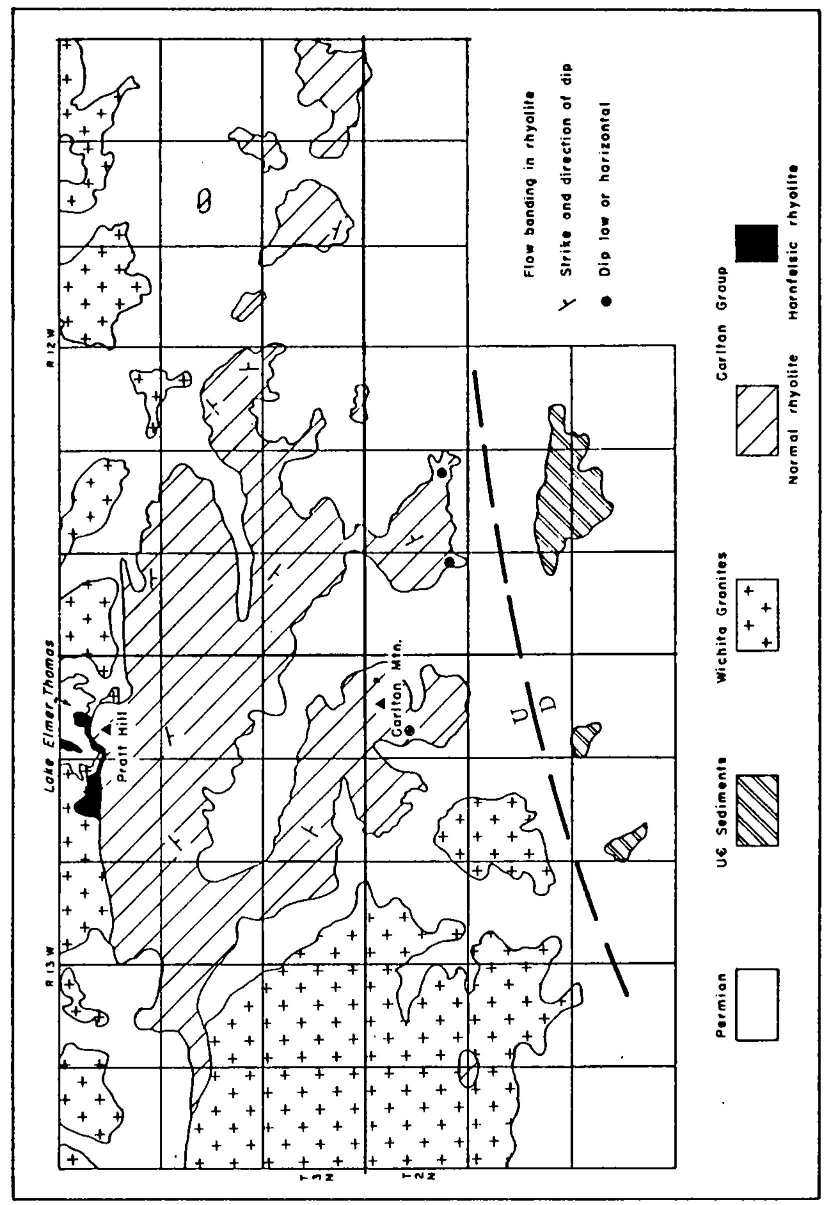

Figure 9. Outcrop map of Carlton rhyolite and Wichita granite in the Fort Sill Military Reservation, Comanche County. Modified from Schoonover (1948) by Ham and Denison, 1959.

Wichita Mountains. Relicts of feldspar phenocrysts remain in the rock, but the originally flow-banded glassy groundmass is now a crystalloblastic aggregate of quartz, feldspar, sieved biotite and hornblende, and iron ores (pl. IX-6). Some of the xenoliths are as much as 60 feet long. An entirely similar rhyolite hornfels was found at a depth of 2,135 feet in the Gulf 1 Inklebarger, SW¼ SW¼ SW¼ sec. 3, T. 1 N., R. 20 W., in east-central Jackson County (pl. IX-5). Another area of large inclusions of rhyolite in granite is on the northwest slope of Koehler Hill, around the common corner of secs. 4, 5, 8, 9, T. 2 N., R. 13 W., but in this area the rhyolite has not been converted to hornfels.

With respect to other basement rocks of southern Oklahoma, the relative age of the Carlton Rhyolite Group is established by several kinds of geologic observations. It overlies and therefore is younger than the extrusive Navajoe Mountain Group and the Tillman Metasedimentary Group. It also overlies intrusive rocks of the Raggedy Mountain Gabbro Group, and in the eastern part of the Wichita Mountains it probably was extruded upon an eroded gabbro block that had been uplifted by pre-rhyolite faulting (pl. IV-W). Finally, the Carlton rhyolite is completely unrelated to rocks of the Eastern Arbuckle Province, as they have the much greater age of 1,050 to 1,350 million years.

GENERAL PETROLOGY

The Carlton Rhyolite Group is composed dominantly of a succession of rhyolitic flows interbedded with related tuffs and agglomerates. Flows of basalt and sills of diabase accompany the rhyolitic rocks. Feeders and irregular masses of intrusive rhyolite, as well as hornfelsic rhyolites that have been formed by the intrusion of granite, are included within the group, but as mapped in southern Oklahoma virtually all the rocks are extrusive elements of a widely distributed and thick volcanic field.

That many of the rhyolites were originally glassy is abundantly shown by the preservation of perlitic, spherulitic, and delicately flow-banded structures in the flows, and by the occurrence of relict glass shards in the tuffs (pl. VIII). Glass has not been preserved in the 500-million-year-old rhyolites, but has been converted into a devitrified mosaic of fine-grained quartz and feldspar. Although the term aporhyolite or devitrified rhyolite is applicable, there has

been such little change from the original character, except for devitrification, that the terms rhyolite or rhyolite porphyry can equally well be used. Moreover, because it cannot be proved whether some of the thicker flows crystallized with a glassy or a holocrystalline groundmass, the simple nongenetic term "rhyolite" is to be preferred.

Most rocks of the Carlton Group are porphyritic, containing well-defined pink phenocrysts of perthite and acidic plagioclase 2 to 4 mm long (pls. VII, VIII). The larger phenocrysts are generally multigranular. Quartz phenocrysts, both well crystallized and strongly resorbed, also are present in most specimens but range widely in percentage composition. Modal point-counts made on the four chemically analyzed samples given in table 18 show that the percentage of quartz and feldspar phenocrysts in Carlton rhyolite ranges from 10.8 to 22.5, and averages 16.8. In these four samples the quartz phenocrysts range from 0.2 to 5.6 percent of the rock, and the feldspar phenocrysts range from 9.0 to 22.0 percent, averaging 14.8 percent. Small magnetite grains and phenocrysts make up as much as 1.7 percent in some rocks, and the remainder is felsitic groundmass.

Rhyolites interpreted as normal flows are either strongly banded, blocky and without flow lines, prominently layered as if separated by widely spaced thin flow bands, or massive. On Bally Mountain, perlitic cracks and spherulites are restricted to the flow-banded, blocky, and prominently layered beds, whereas the massive sheets lack these structures and may have been emplaced in part with a holocrystalline groundmass, as slowly cooled thick flows or perhaps as sills. In the large outcrop area of the Fort Sill Military Reservation much of the Carlton rhyolite is massive and is cut by closely spaced joints, yet flow-banded rhyolite is common and Schoonover (1948, pl. V) was able to record many dips and strikes of the banded layers. His map shows the rhyolite in an area 10 miles long and 3.5 miles wide. It has the form of a syncline that plunges eastward, away from granite outcrops on either side. These relations are suggestive of a flow sequence intruded at the base by a granite sill and later folded into a syncline. Welded tuffs are known within the sequence, and perlitic structure indicating an original glassy groundmass is present in the rock along the south shore of Lake Elmer Thomas. Lack of continuity of the beds prevents an esti-

TABLE 7.—PERCENTAGE OF ROCK TYPES, AND RANGE IN THICKNESS OF BEDS OR FLOWS, IN SELECTED THICK SECTIONS OF CARLTON RHYOLITE

	Bally Mountain Measured section	*Frankfort No. 1 Sparks Ranch C SE SE 32-1S-1W*	*Stanolind No. 1 Perdasofpy SE NW SW 11-4N-12W*	*Shell No. 1 Galloway SE SE SE 21-8N-18W*
Flows	91%	73%	70%	50%
	4-515′	30-550′	15 485′	25-395′
Tuff or agglomerate	6%	16%	18%	38%
	24-85′	10-200′	20-225′	160-1470′
Diabase	3%	11%	12%.	12%
	5-30′	10-90′	20-140′	15-80′
Total thickness penetrated or measured, feet	3,597	4,520	2,610	4,370

mation of the thickness of rhyolite remaining in the Fort Sill area, but the order of magnitude appears to be 1,000 feet or more, within the range of other thick flows in southern Oklahoma (table 7).

Associated with the flows of the Carlton Group are pyroclastic beds of water-laid tuff, welded tuff, and agglomerate (pl. VIII-5, 6; figs. 5, 6). Such pyroclastics are well known on the outcrop at Bally Mountain and Zodletone Mountain. In subsurface they are known in at least eight wells in Beckham, Comanche, Garvin, Greer, Murray, Stephens, and Washita Counties. The thickness of the pyroclastic beds normally is 30 to 200 feet, and their total contribution to the Carlton sequence ranges between 6 and 38 percent (table 7). A continuous sequence of tuffs 1,470 feet thick was drilled in the Shell 1 Galloway well, but owing to structural complexities this footage cannot be safely accepted as stratigraphic thickness.

Most of the tuffs are composed of devitrified glassy shards, angular fragments of rhyolite, and grains of feldspar and quartz. Without exception the tuffs are of rhyolitic composition. Water-laid tuffs are distinguished by their well-defined bedding and heterogeneous composition from the welded tuffs, which are characterized in the best-known examples by elongated shards that are flattened and bent around enclosed crystal grains (pl. VIII-5). It is strange that more welded tuffs have not been recognized in the Carlton

Group. A field of rhyolites, covering at least 17,000 square miles in this region and probably having an original thickness in excess of 5,000 feet, might be expected to contain thick welded tuffs such as described from other areas by Gilbert (1938), Enlows (1955), and Ross and Smith (1961). Many of the massive rhyolites here described as flows may possibly be welded tuffs, which can no longer be recognized following complete devitrification and resulting loss of form of the glass shards.

In addition to devitrification, all rhyolitic rocks of the Carlton Group are at least mildly altered. Virtually all feldspar phenocrysts show some degree of sericitization, many of the rocks are notably silicified, and all show partial or complete chloritization of the few grains of hornblende and biotite they originally contained. Epidote and carbonate minerals also are introduced. The extreme form of alteration is that of the rhyolite hornfels, typically formed where blocks of rhyolite have been caught up as inclusions within an intrusive granite. They are characterized by crystalloblastic aggregates of quartz, feldspar, biotite, hornblende, and iron ores.

A final petrologic character of the Carlton Group is the ubiquitous occurrence of diabasic rocks with the rhyolites. Cross-cutting diabase dikes intrude rhyolite on Zodletone Mountain, and diabasic rocks intrude the rhyolite of the East Timbered Hills and the West Timbered Hills (Uhl, 1932, p. 35-36, 40-46). From subsurface information the diabasic rocks are believed to occur mainly as sills, although some are perhaps flows. In the three deepest penetrations of Carlton rhyolite in southern Oklahoma (table 7), diabase consistently makes up 11 or 12 percent of the sequence, occurring as sills or flows as much as 140 feet thick.

PETROGRAPHY

As studied in thin sections, the Carlton Group is determined to be a diverse suite of rhyolite, rhyolite porphyry, tuff, and agglomerate. The mineralogy is relatively simple and is consistent within rather narrow limits. Most of the variation occurs in the form of numerous textural varieties, which in turn reflect the different modes of origin of the rocks.

Phenocrysts are rarely absent and are invariably perthite, sodic plagioclase, quartz, and iron ore granules. Feldspar phenocrysts predominate. They are either single crystals or complex glomerophenocrysts with as many as five optic units, which appear to grow from a common point. The glomeroporphyries are not uncommon and tend to characterize geographic areas of rhyolite. The outer crystal terminations are euhedral in most plagioclases but tend to be rounded or subhedral in the perthites. Resorption locally plays a major role, resulting in the formation of rounded crystals or phenocrysts with a wormy or spongy appearance. Plagioclase phenocrysts are generally more nearly euhedral than are the perthites. Both feldspars contain finely disseminated hematite that imparts a reddish or pink color. Some plagioclase is nearly colorless. The feldspar phenocrysts are generally less than 5 mm long and rarely comprise more than 20 percent of the total rock.

The perthite is believed to have been precipitated from the magma as a single homogeneous feldspar, probably sanidine, and exsolved during a later period to its present form.

Plagioclase phenocrysts generally are albite. Universal-stage determinations on samples from Bally Mountain and the East Timbered Hills (table 18) show respectively An_4 and An_6.

Quartz phenocrysts are normally rounded and embayed, but locally they show perfectly developed euhedral faces. Shattering is not uncommon. The phenocrysts rarely exceed 3 mm in diameter and generally comprise less than 5 percent of the total rock.

Iron ore phenocrysts are generally smaller than 1 mm, with crystal faces notably absent, and they comprise less than 1 percent of most rocks. Zircon and apatite are commonly associated as partial or total inclusions.

The rhyolitic groundmass represents the most diverse facet of the Carlton Group. Mineralogically it is composed of quartz and feldspar with minor amounts of iron ore, chlorite, apatite, zircon, biotite, amphibole, fluorite, epidote, calcite, siderite, and feldspar alterations. Primary biotite and amphibole are exceptionally rare and occur only in trace amounts.

Massive types of rhyolite are characterized by a felsophyric groundmass. The quartz is intimately and randomly intergrown with feldspar, partly as delicate spicular rods having a length-to-width ratio of 1:5 or more. These spicules are generally associated with vague spherulitic patterns, probably formed during devitrification, and locally they show a crude system of optical orientation. Chlorite occurs in fine shreds, as an intergranular mineral, or as

rare pseudomorphs after a primary femic mineral. Accessory minerals are commonly clotted in groups. Groundmass feldspars contain abundant hematite in the form of dust, irregular grains, and tiny globules.

Banded varieties of the rhyolite are of two general types, one in which the bands are crudely defined and widely spaced and the other in which the banding is delicately and conspicuously defined.

The most delicate banding occurs in the devitrified obsidian-type glasses. In these glasses the bands are mostly recognized by differences in color that are brought out solely by variable concentrations of an iron pigment. The devitrification minerals and their boundaries are poorly defined and difficult to determine petrographically, although some of the optic units appear to be delicate fernlike intergrowths of quartz and feldspar. The devitrification boundaries transect the color bands, indicating an originally homogeneous glass. The fine bands are wrapped around phenocrysts in the direction of flow. Microlite iron ore is partly concentrated along these thin and delicate bands, but such concentration is best developed in the varieties that have thicker and more crudely defined bands.

Crudely defined banding is caused by mineralogic inhomogeneity, chiefly by an alternation of layers enriched either in quartz or feldspar. Bands containing abundant feldspar are more likely to be spherulitic or perlitic, and are more deeply colored, than those bands containing abundant quartz.

A spherulitic groundmass is probably the most characteristic feature of rocks of the Carlton Rhyolite Group. The spherulites may be divided into two types, those crystallized from the primary melt and those caused by devitrification. The occurrence of these spherulites in the widely distributed Carlton Rhyolite Group indicates that the original rock was a glass of extrusive origin.

Spherulites interpreted as of primary origin locally have a marked color contrast as compared to that of the groundmass, the spherulite itself being paler near the core and deeper reddish brown near the margins. Femic mineral pseudomorphs or iron ore needles occur as subparallel inclusions within radial primary spherulites. A primary origin also is suggested in those rhyolites wherein the spherulites are considerably finer grained than the enclosing groundmass. Radial growths around phenocrysts are found as primary features but can also be caused by devitrification, in which case the spherulites are not well defined. Bands or trails of discrete spherulites are found in modern glasses but they, too, can be caused by the devitrification of feldspar-rich flow bands.

Primary spherulites result from direct precipitation of radiating needles from a melt and may be associated with a groundmass that originally was either glassy or holocrystalline. Secondary spherulites are composed of radiating quartz-feldspar aggregates derived by devitrification of glass. Spherulites interpreted to have been formed secondarily, by devitrification of glass, occur in rhyolites of the Carlton Group, although they are more easily identified by their lack of primary features than by their own characteristics. Locally, a secondary origin can be shown where a devitrification spherulite transects a well-defined flow line or is incongruous with the rock texture.

Every spherulite that could be identified petrographically was found to be composed of a delicate quartz-feldspar intergrowth. These are best recognized at the coarser outer margins of spherulites. Some spherulites are possibly composed of nearly pure quartz or feldspar, but their compositions could not be positively ascertained under the petrographic microscope.

Perlitic rhyolite porphyries are common in the Carlton Group (fig. 10A), and recognition of this rock is important in demonstrating the widespread occurrence of glassy extrusive flows. They can be identified even in the small cutting chips that are available from most deep wells. The perlitic cracks normally are filled with chlorite or iron ore, which serves to outline each perlite grain. The devitrified optic units, some of which are delicate fernlike intergrowths, are parallel or subparallel to the cracks in large smooth whorls. Quartz and sericitized perlite cores containing opaque microlites occur in some rocks.

Many areas of the surface and subsurface are characterized by rhyolite having a groundmass composed of a granular mosaic of quartz and feldspar. Within the groundmass are localized groups of discrete quartz masses that are optically continuous. This fact was noted by Hoffman (1930), who called the rhyolite porphyries of the Fort Sill area "granophyres." The groundmass mosaic, however, is locally granoblastic in texture and appears to have been caused by complete recrystallization of a glassy or felsitic ground-

mass, with the resulting destruction of primary spherulitic and perlitic structures. This weak hornfelsic reconstitution is probably the result of intrusion of Wichita granites into the lower part of the Carlton Group.

One bed or more of tuffaceous rhyolite is found in most wells penetrating a substantial thickness of rhyolite in southern Oklahoma. In the three rhyolite wells logged on plate III and summarized in table 7, tuffaceous rhyolite makes up 16, 18, and 38 percent of the penetrated thickness. These pyroclastic rocks are particularly significant because they prove unequivocally the extrusive origin for a substantial part of the Carlton Rhyolite Group.

Welded tuffs are found both in the subsurface and in surface exposures. They invariably contain fragments of feldspar crystals and, less commonly, quartz. The character of the relict shards is well defined around crystal grains, where definite contortion and flattening occur. Early silicification is most helpful in preserving the shard outlines. It is believed that welded tuffs are more common than petrographic evidence would lead one to suspect, but devitrification and reconstitution have generally destroyed the evidence on which an interpretation can be based.

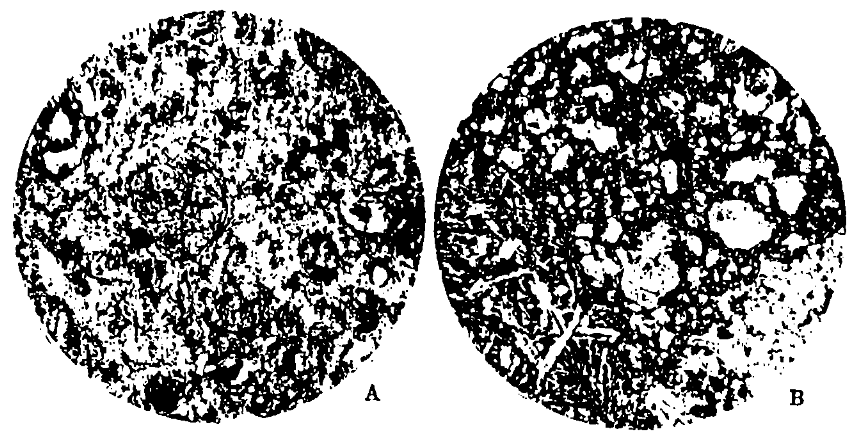

Figure 10. Photomicrographs of Carlton rhyolite (Colbert porphyry) from the West Timbered Hills, NE¼ SE¼ NE¼ sec. 10, T. 1 S., R. 1 W.

A. Rhyolite porphyry. Devitrified perlites are common in the groundmass of a rhyolite containing sparse phenocrysts. Ordinary light. Field diameter: 2.8 mm.

B. Agglomerate. Fragments of basalt (lower left) and rhyolite (lower right), together with smaller crystal and lithic debris, are set in a matrix of iron-rich dust. Ordinary light. Field diameter: 2.8 mm.

At Bally Mountain and Zodletone Mountain coarse agglomeratic tuffs have been found containing lithic fragments as much as 30 cm (12 inches) long. In subsurface such rock is particularly difficult to identify because few cutting chips exceed 6 mm in diameter. However, if cutting chips from a restricted sequence are composed of diverse rhyolite types in the presence of finer tuffaceous fragments, it can be reasonably inferred that an agglomerate has been penetrated. Cores would furnish conclusive information, but to our knowledge no cores of agglomerate have been cut in southern Oklahoma.

The agglomerates generally are composed of large fragments of perlitic rhyolite porphyry and other types of rhyolite set in a matrix of finer lithic debris, normally enriched in iron (fig. 10B). This matrix is tough and thoroughly encloses the fragments, so that they have no tendency to weather out as loose blocks.

The finer tuffaceous rocks contain feldspar, quartz, iron ore, and lithic detritus in a dusty matrix. Where sorting and bedding are well defined, as in bed 4 of the Bally Mountain measured section, a water-laid origin and lacustrine environment are suggested. Some of the bedding layers in such rocks are as thin as 0.2 mm. Bentonitic clays, commonly derived from such rocks elsewhere, have not been recognized in southern Oklahoma.

Most of the rhyolites are at least slightly altered beyond the stage of devitrification, and new minerals have been introduced. Feldspar phenocrysts commonly contain unoriented sericite flakes and are clouded by iron ore dust as well as by the products of the process generally described as kaolinization. "Kaolinization" appears generally to result from the development of vacuoles rather than from the formation of clay minerals. Sericite in suboriented shreds completely replaces phenocrysts of feldspar at some localities. Local subsurface areas are notable for extensive replacement of feldspars. The Shell 1 Galloway, sec. 21, T. 8 N., R. 18 W., penetrated several thousand feet of such highly altered rhyolites. The alteration probably is a late deuteric phenomenon associated with the intrusion of Wichita granites.

Chlorite and, less commonly, biotite are found as secondary veins and replacement masses. Chlorite is generally present and occurs as finely disseminated shreds, as a replacement of former mafic minerals, as veins, and as small masses within the feldspars.

Where particularly abundant, chlorite imparts a greenish color to the rhyolite groundmass. Both biotite and chlorite are in the form of small unoriented shreds.

Silicification is erratic but quartz veinlets and chalcedonic replacement masses are not uncommon. Certain beds at Bally Mountain, in the Blue Creek canyon area, and on the Fort Sill Military Reservation are extensively silicified.

Calcite is a common secondary mineral, occurring as veinlets, as replacement patches of feldspar, and as irregular masses associated with chlorite in clots with other accessory minerals. Siderite, characterized by a faint but distinctive iron stain, is not uncommon in certain geographic areas of the subsurface. Dolomite appears to be present locally as small perfectly formed rhombohedrons.

Epidote occurs as discrete grains, thin veins, and masses of crystalline aggregates. Crystal inclusions of epidote within feldspar phenocrysts are known. It is a comparatively rare and volumetrically insignificant mineral.

Fluorite occurs as veinlets associated with other accessory minerals and as a rare partial replacement of feldspar phenocrysts.

Rhyolite porphyries occurring several thousand feet below the top of the basement surface are no less altered than those at the surface today. It is therefore incorrect to call this alteration "weathering." The alteration is contemporaneous with the extrusion, or is associated at the very latest with the slightly younger granites.

The carbonates offer a different genetic problem because the rhyolites are overlain by a thick sequence of Upper Cambrian and Ordovician sediments containing calcite, dolomite, and siderite. Carbonates are the youngest minerals in the rhyolites and could have migrated into them from the overlying sediments.

The most advanced stage in the alteration of rhyolites is shown by their conversion to hornfels, in certain areas near granite intrusions. Large xenoliths of rhyolite are included within granite in secs. 7, 18, T. 2 N., R. 16 W. These rhyolites show well-defined relict banding and small ill-defined feldspar phenocrysts. The groundmass is a granoblastic mosaic of quartz and feldspar containing granules of iron ore and small but well-formed sieved grains of biotite and hornblende. Relict phenocrysts of feldspar have indistinct margins and are partly reconstituted into the finer mosaic. The flow lines are well defined under the microscope and consist of alternating quartz-rich and feldspar-rich bands. Rare specimens of Carlton rhyolite from the subsurface, as in the Gulf 1 Inklebarger, sec. 3, T. 1 N., R. 20 W., also are converted to hornfels.

Wichita Granite Group

INTRODUCTION

The dominant outcropping rock in the Wichita Mountains is pink medium-grained granite. As the result of mapping and petrographic study by earlier geologists, notably Taylor (1915), Hoffman (1930), and Merritt (1958), the granitic rocks have been shown to consist of several rock types. They differ appreciably in texture, slightly in mineral composition, and to some extent in age, for intrusive relations indicate at least four separate granite injections, and possibly as many as six. Studies for the present investigation have extended the knowledge of these rocks from the surface into a much broader subsurface region, and they are now known to be present over a total area of not less than 15,000 square miles in southern Oklahoma.

The term Wichita Granite Group is here proposed for this assemblage of closely allied rocks, the name being taken from the mountain system in which they are well exposed. Included within the group are those granites previously mapped on the outcrop as Lugert, Headquarters, Reformatory, Quanah, and Cold Springs, as well as their equivalents in subsurface. Specifically excluded are the rhyolitic rocks of the Carlton Group which, although similar mineralogically, are products of a different geologic environment.

Rocks of the Wichita Granite Group are holocrystalline phases of silicic magma intruded within the Wichita Province. The extrusive and commonly glassy phases of the same magma are found as flows and tuffs of the Carlton Rhyolite Group. Together these groups are widely distributed and are quantitatively of great significance. Each is isotopically dated at 525±25 million years and is assigned a Middle Cambrian(?) age. Rhyolite and granite probably overlap somewhat in time but are essentially time equivalents, representing the latest magmatic stage in the basement-rock history of southern Oklahoma.

Interesting calculations as to the volume of rhyolite and granite in the Wichita Province can be made from the generalized data available (pl. V). Considering the rhyolite to have an area of

17,000 square miles and a thickness of 3,000 feet, its volume would be at least 10,000 cubic miles; and if the granite is only 1,500 feet thick over 15,000 square miles, its volume would be approximately 5,000 cubic miles. The order of magnitude of silicic rock is thus at least 15,000 cubic miles. Both in areal extent and volume, the silicic rocks dominate the basic rocks and must be considered the fundamental igneous-rock units of the Wichita Province.

MINERAL COMPOSITION

Granite rocks of the Wichita Province are characterized as perthite-quartz leucogranites. Virtually all are composed of about one-third quartz, two-thirds potassium feldspar that is mostly intergrown with plagioclase, and 2 to 5 percent ferromagnesian minerals. No granite differs appreciably from this composition, and the granite suite therefore bears the stamp of mineralogic homogeneity. Discrete grains of plagioclase, not intergrown microscopically with potassium feldspar, are inconspicuous or absent. This distinctive mineralogic assemblage so characterizes the granitic rocks of the Wichita Group that they can be clearly set apart from granites of the Eastern Arbuckle Province, which normally contain at least 20 percent plagioclase occurring as discrete crystals with microcline-perthite. The mineralogic criteria have been especially valuable because they can be recognized even in the small cutting chips obtained by rotary drilling, upon which most of the subsurface mapping has been based.

Modal analyses of representative granites from the Wichita Group are given in table 8. As determined from the table, the average granite consists of perthite, 62 percent; plagioclase, 2 percent; quartz, 33 percent; and ferromagnesian minerals, 3 percent. In most rocks the dominant mineral is perthite, consisting of a well-defined plagioclase-orthoclase intergrowth. Chemical analyses (table 18) indicate that the normative plagioclase of the perthite is albite, in the An_0-An_7 range; and earlier analyses of feldspars separated from Wichita granites, made in the laboratory of the Oklahoma Geological Survey (Burwell, 1956, p. 18), show that the perthites consist of orthoclase and albite in approximately equal amounts.

Occurring with the perthite in most rocks is a potassium feldspar in which plagioclase intergrowths are not visible. Some of these crystals are intensely clouded with dustlike inclusions and alteration products, whereas others are unaltered and clear. They appear to be orthoclase but probably are perthites in which the plagioclase is submicroscopically intergrown. Chemical analyses support this conclusion, as the analyses of five Wichita granites given in table 18 show 32 to 36 percent normative albite, regardless of the percentage of apparent "orthoclase" in the rock.

In a few outcrop areas of the Wichita Mountains and locally in subsurface, microcline perthite is the exclusive feldspar. Two prominent examples of microcline-bearing Wichita granites are from Camelback Mountain and the Gulf 1 Back well.

Perthitic potassium feldspar, with a gross percentage range of 52 to 65 percent, is the most abundant mineral in all granites of the

TABLE 8.—MODAL ANALYSES OF GRANITE FROM THE WICHITA GRANITE GROUP

	Fine-grained granite		*Coarse-grained granite*			*Medium-grained granite*				
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Orthoclase-perthite	52.4	26.2	65.8	58.9	—	64.4	15.4	62.5	—	9.7
Microcline-perthite	0.4	tr	tr	—	58.8	—	—	—	63.7	—
Albite-oligoclase	6.1	4.8	4.2	2.1	—	—	2.5	3.9	—	2.0
Micropegmatite	—	49.2	—	17.7	—	—	72.8	0.8	—	78.6
Quartz	35.3	17.7	25.1	19.1	38.8	31.8	3.5	30.0	34.8	6.8
Biotite	3.3	2.1	0.6	tr	0.8	—	—	0.6	1.5	0.4
Hornblende	0.4	0.7	2.3	1.4	—	0.3	2.1	1.3	—	0.3
Riebeckite	—	—	0.6	tr	0.5	2.6	—	—	—	—
Magnetite	0.9	0.7	0.2	0.8	0.4	0.8	2.0	0.6	—	1.8

1. Headquarters granite, average of 2 samples, normal rock (Merritt, 1958, p. 32).
2. Headquarters granite, average of 4 samples from contact zone with Reformatory granite (Merritt, 1958, p. 32). Micropegmatite ranges frm 20.2 to 85.1 percent.
3. Reformatory granite, average of 8 samples in outcrops west of Lake Altus (Merritt, 1958, p. 37).
4. Reformatory (Flat Top) granite, average of 3 samples in outcrops south of Lake Altus (Merritt, 1958, p. 38).
5. Leucogranite, core at depth of 8,011 feet, Gulf No. 1 Back, NW¼ SE¼ sec. 34, T. 9 N., R. 22 W., Beckham County (table 18, this report).
6. Quanah granite near Lost Lake, SE¼ SE¼ NW¼ SE¼ sec. 21, T. 3 N., R. 14 W., Comanche County (table 18, this report).
7. Granite mapped by Hoffman as Lugert, top of Mt. Scott, NE¼ SE¼ sec. 11, T. 3 N., R. 13 W., Comanche County (table 18, this report).
8. Lugert granite, average of 4 samples from Lake Altus area (Merritt, 1958, p. 46).
9. Lugert granite, quarry of Century Granite Co., Camelback Mtn., SW¼ NW¼ sec. 20, T. 5 N., R. 18 W., Kiowa County (original).
10. Lugert granite, average of 8 samples from the Cooperton area (Hull, 1951, p. 24).

Wichita Group. Nonintergrown plagioclase, normally sodic oligoclase in the range of An_0 to An_{12}, locally contributes as much as 6 percent to the bulk composition of the granites, occurring in the form of discrete grains and as the central core of larger perthite crystals. As determined from the modal analyses, the range of free plagioclase is from 0 to 6 percent, and the approximate average for all granites is 2 percent.

Quartz is the second most abundant constituent. It occurs in the hypidiomorphic granular rocks as irregular interstitial grains within the feldspar framework, in the porphyritic rocks both as phenocrysts and as groundmass intergrowth, and in other rocks solely as micropegmatitic intergrowths with perthite. Relative abundance of these types is highly variable in Wichita Province granites and is discussed in more detail below. Total percentage of quartz is inversely proportional to that of feldspar, ranging from 25 to 39 percent and averaging 33 percent (modal analyses). Calculations of normative quartz from the five chemical analyses of table 18 show approximately the same average, 32 percent, and a range of 30 to 33.5 percent.

Brown biotite, green hornblende, and magnetite are the commonly associated minerals in granites of the Wichita Group. Riebeckite or aegirite locally occurs instead of hornblende, or with it, but no other ferromagnesian mineral contributes as much as 1 percent to any rock in the group. Biotite and hornblende are most abundant, occurring together in most rocks as the principal dark constituents, yet commonly one or the other is present in trace amounts, or is absent. A remarkably low dark-mineral content of 1.5 to 5 percent characterizes the normal phases of all granites.

In contact phases of granite against gabbro, basalt, and microdiorite, or where numerous inclusions of these rocks are present, the content of hornblende and biotite increases from the normal maximum of about 4 percent to as much as 17 percent. Much of this additional hornblende and biotite has been derived from pyroxene of the older rock. New hornblende of the granite is thus characterized locally by its content of relict pyroxene. A large increase in femic minerals generally is accompanied by an increase in plagioclase to more than 20 percent, with the resulting formation of such rocks as the Cold Springs granite, granodiorite, and quartz diorite (Taylor, 1915, p. 62, 71-74; Walper, 1951). Only small areas, however, are made up of these hybrid assimilation rocks. The normal leucogranite of the region, in particular that near Granite, Lugert, Headrick, Snyder, and Mount Scott, is characterized by a low content of hornblende and plagioclase. It nevertheless contains numerous small basic inclusions, through the assimilation of which the original character of the granite has been at least slightly modified.

TEXTURE

Excepting the obviously different mineralogy that is locally developed in the assimilation rocks, the most conspicuous variable of the Wichita granites is in texture. The full range encompasses a spectrum of grain size that grades from 0.3 mm to 20 mm, of texture that grades from hypidiomorphic equigranular to strongly porphyritic, and of micrographic intergrowth that grades from spectacular development to complete absence (pl. X).

These variables reflect slight differences in character of the magma as well as the different environments under which the magma was injected and cooled. Where the magma contained crystals of feldspar and quartz, and was injected as a sill, or cooled near an intrusive margin, the resulting rock is porphyritic. The Lugert granite porphyry of the Lake Altus area and the granite near Cooperton are examples. Where cooled in larger chambers, or in presence of more water, the magma consolidated into even-textured granites of the Reformatory and Quanah types, in which the grain size is 10 to 20 mm. Intermediate types, cooled as smaller plutons and thick sills, make up most of the Wichita granites. Their normal grain size is 2 to 4 mm, and their common texture is hypidiomorphic equigranular to slightly inequigranular. Phenocrysts of gray perthite, rectangular to ovate in outline, give a faintly porphyritic appearance to many of these rocks.

Micrographic intergrowths of quartz in potassium feldspar, also known as micropegmatite or as "granophyric texture," have been recognized in granites of the Wichita Mountains since the early work of Taff (1904, p. 61). This distinctive intergrowth is now known to occur, at least as local phases, in every body of granite exposed in the mountains, and it is widely distributed in subsurface (pl. XI). When Hoffman (1930) mapped and studied outcrops in the eastern part of the Wichita Mountains region, he was so impressed by this intergrowth that he called all the quartz-feldspar rocks

granophyres, dividing them into five named units. In more recent years, use of the term granophyre has been propagated and extended by Hamilton (1956, 1959).

To what extent can these rocks be called granophyres? Is it permissible to call all of them granophyres if each body contains a little micropegmatite locally? We object to this usage because characterization of the silicic rocks of the Wichita Province as "dominantly granophyres" leads to the formulation of broad generalizations and serves to conceal useful information about the form and genetic relations of the several rocks. In this respect Hoffman's usage is both misleading and partly inaccurate. What is here called Carlton rhyolite and Quanah granite were named Carlton granophyre and Quanah granophyre by Hoffman. Yet neither of these rocks is characterized by a dominance of granophyric intergrowth; and, even more objectionable, the rocks were formed in completely different environments, for the Carlton consists mainly of extrusive flows and tuffs whereas the Quanah is an intrusive coarse-grained granite. For purposes of mapping and interpretation, it is essential that proper distinction be made. The granophyres must be distinguished as such only where granophyric intergrowth actually characterizes the rock.

The next question concerns the distribution and relative abundance of the granophyric and nongranophyric granites. Are certain intrusive bodies typically granophyric and others typically nongranophyric? Mapping of virtually all the granite outcrops in the Wichita Mountains, together with an examination of more than 600 thin sections of these rocks, indicates characteristic regional patterns and age relations. Our conclusions are summarized in table 9. Four granites are present in the Lake Altus area, three of them nongranophyric and one granophyric. In much of this area, and over most of the region itself, there generally are two principal granite types—older granophyric granite intruded by younger nongranophyric granite. The relative proportions of the two rocks are highly variable from place to place, yet regionally the total area of each rock is approximately the same. These granites are locally in sharp contact, and the dissimilarity between them indicates a difference in the environments under which the micrographic intergrowth was favored or rejected.

To these general observations we can add the knowledge available from our subsurface studies. Micrographic Wichita gran-

TABLE 9.—DISTRIBUTION OF PRINCIPAL GRANITES IN THE WICHITA MOUNTAINS
(In each area the oldest granite has the lowest number)

Mount Scott-Wildlife Game Refuge Area
1. Micrographic medium-grained granite ("Lugert," large area)
2. Nonmicrographic coarse-grained granite (Quanah, small area)

Cooperton Area
1. Micrographic medium-grained granite ("Lugert," small area)

Snyder-Mountain Park-Headrick Area
1. Micrographic medium- to fine-grained granite ("Lugert," moderate area)
2. Nonmicrographic medium-grained granite containing abundant inclusions ("Lugert," moderate area)

Lake Altus Area
1. Nonmicrographic microgranite (Headquarters, small area)
*2. Nonmicrographic coarse-grained granite (Reformatory, small area)
*3. Micrographic granite porphyry and microgranite ("Lugert," small area)
4. Nonmicrographic medium-grained granite containing numerous inclusions ("Lugert," moderate area)

* Age relations between 2 and 3 are not fully established.

ite was found in 24 wells, nonmicrographic granite in 19 wells, and mixtures of both types in 3 wells. The only generalization resulting from this study, however, is that granite intrusive into the lower or basal part of the Carlton rhyolite is characterized by micrographic intergrowth. So far as is known, all granite bodies of this type are sills, of which the roof is rhyolite and the floor is basalt, gabbro, or graywacke.

In summary, the most significant variable in granites of the Wichita Granite Group in southern Oklahoma is their wide range in texture. The textural gradation from very fine to very coarse mainly reflects differences in cooling environments. A second major variable concerns the extreme range in percentage of micrographic intergrowth, which characterizes about half the rocks and is absent in the other half. More knowledge about the origin of this interesting micrographic intergrowth would doubtless be of help in regional interpretation. Observations from the present study indicate that the coarsest granites (>10 mm) are nonmicrographic, whereas the sills that intrude the Carlton are micrographic. Intermediate types are either micrographic or nonmicrographic, apparently depending upon such variables as the character of the magma, depth and form of the intrusion, and proximity to an intrusive contact. Because the Wichita granites cannot be fully characterized by micrographic intergrowth, any more than by medium grain size, we do not use the term "granophyre" but favor the more general term "granite," which is then qualified by the proper mineralogic and textural adjectives. Moreover, it is the distinctive mineralogy rather than micrographic intergrowths that distinguishes the Wichita granites from those of the Eastern Arbuckle Province.

DISTRIBUTION, FORM, AND RELATIONS TO OTHER ROCKS

The total area of Wichita granite, mostly in southern Oklahoma but to a lesser extent in adjoining parts of Texas, probably is about 15,000 square miles. Three principal types of occurrences are indicated. In the central Wichita block, granite occurs as plutons and sills injected into and above gabbro and into the lower part of rhyolite flows. In a region equally as large—that lying between the Wichita and Arbuckle Mountains—thick granite sills have roofs of rhyolite and floors of basalt or graywacke. South of the central Wichita block, Wichita granite is presumed to be widely present as plutons injected into a roof of clastic sediments of the Tillman Group, converting them on a regional scale into biotite meta-graywackes. Near intrusive contacts the degree of metamorphism is greater, the sediments being converted into biotite schists and hornfels. The granite bodies intruding a roof of sediments were doubtless emplaced more deeply than the granite sills injected into rhyolite flows, and thus intrusion of the granite magma into an upper and a lower environmental zone is clearly implied. Nevertheless, the plutons and thick sills of Wichita granite are typical intrusions of the epizone, as this term is used by Buddington (1959). Those intrusions into the lower part of the Carlton rhyolite were emplaced at a depth no greater than the thickness of the rhyolite flows, which is known to range approximately between 2,500 and 5,000 feet.

The concept that the Wichita granites are the result of differentiation of a large gabbroic mass was proposed by Hoffman (1930) and more recently discussed by Hamilton (1956, 1959). Our data do not support this conclusion, but indicate that the granites and rhyolites are considerably younger than gabbro and have a much greater geographical extent.

Central Wichita block.—Granitic rocks of the Wichita Group are best known in the Wichita Mountains region, where the outcrop area alone is 65 miles long and 25 miles wide. Subsurface studies show, however, that the principal area of granite is a crudely rectangular block approximately 110 miles long and 30 to 40 miles wide, trending northwestward and coinciding approximately with that structural segment called the Wichita uplift or central Wichita block (pl. V). In the eastern part of the block the uplift is greatest, and here the granite is exposed in the form of hills as much as 1,100 feet high (Mt. Scott). Previously covered by flat-lying Permian sedimentary strata, the hills have been exposed by removal in post-Cretaceous time of the easily eroded sediments. The process of erosion is continuing, now exposing as small hills the peaks of mountains that are mostly buried.

Within this area the basic structural pattern is that of an enormous anticlinal fold, sharply cut off and downthrown on the north by a system of northwestward-trending faults. Raggedy Mountain gabbro, the oldest igneous rock, is present upon the outcrop and beneath Permian strata in subsurface, along the axial line of greatest uplift. Intruded into the gabbro is a complex of granite plutons and sills, generally in the form of one or more sheets that lie above the principal gabbro body. Above the granite is Carlton rhyolite. The rhyolite is extensively preserved along the northeast flank but has been mostly eroded, except for outliers, on the southwest flank. In terms of regional distribution the basement rocks are thus arranged somewhat like layers, gabbro being overlain by a sheet of granite, and the granite being overlain by flows of rhyolite. Upon erosion of the uplifted anticlinal block, the upper two layers were successively stripped away and the underlying gabbro was thereby exposed.

In this area much of the granite is interpreted to be a complex of sills intruded between gabbro and rhyolite. Intrusive relations are shown at the upper and lower contacts. The overlying rhyolite is generally eroded away but its contact with granite can be studied at a few localities. Intrusive granite has converted rhyolite to hornfels in the Fort Sill Military Reservation (fig. 9; pl. IX), in the Gulf 1 Inklebarger well (pl. IX), and in outcrops near Snyder at the southern edge of the Wichita Mountains (pl. IX). A chilled contact of granite with rhyolite is known in the Perdasofpy well, discussed below.

Contact relations of the Wichita granites with Raggedy Mountain gabbro can be studied in outcrops of the Wichita Mountains and can be generally inferred from the subsurface study. In all the southern Oklahoma region, it is only in this central Wichita block that granite is known to occur with gabbro. Intrusive relations of granite into gabbro are so widespread that the general premise of granite's being younger than gabbro is clearly established. Inclusions of gabbro and anorthosite are common in granite at or near many contacts, the inclusions showing alterations that range from (a) the conversion of diallage to hornblende and biotite, generally accompanied by the introduction of perthite and quartz, to (b) the formation of hornblende-plagioclase hornfels. Micropegmatite and quartz also are introduced locally into the host gabbro. On a regional scale the granites transgress different rocks of the layered gabbro body, occurring at different localities upon diallage gabbro, anorthosite, olivine gabbro, troctolite, and quartz diorite. Finally, the time of formation of the gabbro is separated from the time of formation of the granite by a period of faulting, uplift, and erosion, as discussed in the last section of this report. The exposed gabbro surface is believed to have been covered by rhyolite flows, the granite being then injected along the contact between these rocks.

In outcrops of the Wichita Mountains some of the granites occur as epizone plutons that intrude slightly older granite of the Wichita Group. Notable are the coarse-textured Reformatory granite of the western area and the equally coarse-textured Quanah granite of the eastern area. Each of these granite bodies has a surface area of several square miles, yet their area is small compared to that of the granite occurring in the form of sills.

Area south of the Wichita Mountains.—Other segments of Wichita granite extend south of the central Wichita block into Jackson, Tillman, and Cotton Counties (pl. I). In eastern Jackson County, around the Altus dome, well control is so concentrated that we are able to interpret a sill of granite injected between an underlying flow of basalt and an overlying flow of rhyolite. In Tillman County the country rock penetrated by drilling is mainly graywacke and schist of the Tillman Metasedimentary Group. Metamorphic grade in some wells increases downward from biotitic graywacke to hornblende hornfels, presumably the result of intrusion by an underlying granite. Wichita granite is believed to be widely present as irregular plutons intruding the metasediments of this area. These plutons probably are the cause of the metamorphism, and are responsible for the structural consolidation of the area.

Extending southeastward from the Wichita Mountains outcrops, through a part of Comanche County and across central Cotton County, is a long and narrow subsurface band of Wichita granite (pl. I). The control wells are widely spaced, but sufficient information is available to indicate that the granite was emplaced as a sill between Tillman metasediments and Carlton rhyolite. Here the granite has no evident relation to gabbro, as the floor of the sill is metamorphosed graywacke and the roof is rhyolite. The three wells in this band have yielded cuttings which are exclusively micrographic granite.

Area between Wichita Mountains and Arbuckle Mountains.—Three wells drilled deep into basement rocks show that Wichita granite is present in the broad area between the Wichita and Arbuckle Mountains. Each well was drilled through a thick section of Carlton rhyolite, and then penetrated 600 to 1,500 feet of micrographic granite below it. This rock is assigned without question to the Wichita Granite Group, as it can be clearly distinguished from granites of the Eastern Arbuckle Province. The great significance of these wells lies first in the demonstration that the Wichita granite extends eastward for 65 miles into the western part of the Arbuckle Mountains; second, that the granite is overlain by rhyolite, as it normally is in the Wichita Mountains; and third, that the wells provide definitive information about the thickness and intrusive form of the granite.

One of the wells near the Arbuckle Mountains is the Sohio 1A Kennedy, NW¼ NW¼ SE¼ sec. 26, T. 1 N., R. 2 W., Garvin County (well Gv-8). At a depth of 5,597 feet, under Reagan Sandstone, Carlton rhyolite was encountered and was drilled to the depth of 8,920 feet, for a total apparent thickness of 3,323 feet. The underlying rock, drilled to the total depth of 9,990 feet, for an apparent thickness of 1,070 feet, is composed entirely of Wichita granite. Micrographic granite characterizes the upper 600 feet, whereas the bottom 500 feet is hypidiomorphic to faintly micrographic. This well was drilled near one of the major faults of the region in an attempt to drill through the overthrust plate of the fault and into oil-productive strata below. The well was abandoned while still in Wichita granite, and thus no information as to the character of the

underlying rock is available. Some question also exists about the structural attitude of the rocks in this well because of its proximity to the large fault.

No structural complications are indicated, however, at the site of the second deep test near the western edge of the Arbuckle Mountains, in the Frankfort 1 Sparks Ranch, C SE¼ SE¼ sec. 32, T. 1 S., R. 1 W., Murray County (well Mr-1). A log of the basement rocks in this well is illustrated on plate III. Under Reagan Sandstone, the well penetrated 4,525 feet of Carlton rhyolite and 1,529 feet of micrographic Wichita granite. The well was abandoned as a dry hole at a total depth of 12,884 feet. It is a singular fact that the Sparks well, drilled within full sight of the West Timbered Hills, on the flank of the well-known Arbuckle anticline in the Arbuckle Mountains, has yielded the maximum drilled thickness of both Carlton rhyolite and Wichita granite. Wells drilled deeper into Wichita granite have been reported, but we have not been able to confirm the reports by sample examination.

In the Sparks well, just as in other localities where granite underlies rhyolite, we interpret the granite to be an intrusive sill. Minimum thickness of the sill is 1,500 feet. The underlying rocks are unknown but are presumed to be basalt or graywacke.

What is probably the most significant basement-rock well in southern Oklahoma was drilled on the northeast flank of the Wichita Mountains, only 8 miles from Mt. Scott. It is the Stanolind (Pan American) 1 Perdasofpy, SE¼ NW¼ SW¼ sec. 11, T. 4 N., R. 12 W., Comanche County (well Cm-1). The samples from this well, together with the seismic profile on the basis of which the well was drilled (Widess and Taylor, 1959), have established numerous concepts that are fundamental to regional geologic interpretation.

The log of the Perdasofpy well is illustrated on plate III. The succession penetrated under Reagan Sandstone was Carlton rhyolite, 2,590 feet; micrographic Wichita granite, 615 feet; and basaltic rocks of the Navajoe Mountain Group, 1,049 feet. The granite has chilled upper and lower contacts and is definitely a sill.

Here the relations are conclusively apparent. Wichita granite is intruded as a sill at the base of the Carlton rhyolite. The underlying rocks that make the floor of the sill are not gabbro, as at Mt. Scott, but spilite, basalt, and tuff of the Navajoe Mountain Group. This granite sill is not related to gabbro, and, conversely, the thick basalts in the well are not represented in the nearby outcrops. By means of this well, however, the Navajoe Mountain Group is definitely extended from the south side of the Wichita Mountains to the north side, and into the Southern Oklahoma geosyncline.

Another relation clearly established by the Pérdasofpy well is that the granite sill was injected along the contact between two different kinds of rocks. A similar relation is believed to hold true for most bodies of concordantly injected Wichita granite in southern Oklahoma.

Extension of Wichita Granite Group into Texas.—The Wichita Granite Group is confined mainly to southern Oklahoma, but a small part of it extends in subsurface about 25 miles westward, into Collingsworth and Wheeler Counties of the Texas Panhandle. It occurs there in association with diorite identical to that in the Raggedy Mountain Group of Beckham County, Oklahoma. Although its boundaries are indefinite, owing chiefly to a lack of well control, the Wichita granite probably is an intrusive sheet above diorite and below Carlton rhyolite, just as it is in southwestern Oklahoma.

In the northern part of the Texas Panhandle, Flawn (1956) correlated the granitic rocks of the buried Amarillo mountains with those of the Wichita Province of Oklahoma. Isotopic age determinations now show that most of this correlation is incorrect, as all the dated granites of the Texas Panhandle are Precambrian. They have ages of 1,200 million years or more (Wasserburg and others, 1962; Denison, 1963) and therefore are much older than the 500-million-year granites of the Wichita Group.

CHEMICAL COMPOSITION

Five original analyses of granites from the Wichita Group are given in table 18, complete with calculated norms and with modal analyses determined by point counts from thin sections. Included are analyses of two different granites from outcrops in the eastern area of the Wichita Mountains region, two different granites from the western area, and a granite at a depth of 8,011 feet from a well drilled 15 miles beyond the western edge of the Wichita Mountains outcrops.

These rocks are closely similar in chemical composition. The sum of SiO_2, Al_2O_3, Na_2O, and K_2O accounts for 94 to 97 percent; and of the remaining constituents, only Fe_2O_3, FeO, and CaO are present in amounts exceeding one percent. The granites thus show a distinctive composition, compatible with their petrologic characterization as quartz-perthite leucogranites. Their silica content of approximately 75 percent likewise is distinctively high, as it is nearly 4 percent higher than the "average granite of all periods" (Daly, 1933, p. 9).

Additional analyses of the Wichita granites, available from published reports and from the files of the Oklahoma Geological Survey, permit a more thorough chemical characterization. Chemical analyses of 13 samples (7 nonmicrographic, 6 micrographic) are summarized in table 10 and the averages are compared with those of Carlton rhyolite. The average values are so similar that a strong chemical relationship is demonstrated. Texture is the only promi-

TABLE 10.—CHEMICAL ANALYSES (ESSENTIAL CONSTITUENTS) OF MICROGRAPHIC AND NONMICROGRAPHIC GRANITES OF THE WICHITA GROUP COMPARED WITH CARLTON RHYOLITE

	SiO_2	Al_2O_3	Fe_2O_3	FeO	CaO	Na_2O	K_2O
Nonmicrographic granites							
1.	75.36	12.18	1.06	1.09	0.39	4.15	4.80
2.	74.14	12.97	1.07	1.20	0.48	4.61	5.30
3.	76.79	12.35	0.90	0.43	0.51	4.23	4.32
4.	72.16	13.52	1.43	1.87	1.03	4.10	4.92
5. (Av.)	74.91	12.51	1.09	1.12	0.51	4.21	4.82
Micrographic granites							
6.	72.04	12.70	2.49	1.57	1.43	3.90	4.25
7.	73.61	11.97	2.34	1.51	1.38	3.76	4.32
8.	75.8	12.1	1.5	0.5	0.5	3.6	4.9
9. (Av.)	74.79	12.15	1.78	0.88	0.81	3.65	4.72
All granites							
10. (Av.)	74.86	12.34	1.41	1.01	0.65	3.95	4.77
Carlton rhyolite							
11.	73.31	12.18	1.97	1.40	0.78	3.76	4.29

1. Average of 4 nonmicrographic granites (table 18, this report).
2. Reformatory granite (Taylor, 1915, p. 21). Locality not given but probably from Quartz Mountain or near the town of Granite, where nonmicrogaphic coarse-grained Reformatory granite crops out extensively.
3. Lugert nonmicrographic granite, quarry of Century Granite Company (Merritt. 1958, p. 43).
4. Nonmicrographic granite, SW¼ NW¼ NE¼ sec. 19. T. 3 N., R. 14 W. Okla. Geol. Survey no. GWC-428; analyzed by Doris Thaemlitz, Rock Analysis Laboratory, University of Minnesota, September 1954.
5. Average of the above 7 nonmicrographic granites.
6. Micrographic granite, top of Mt. Scott (table 18, this report).
7. Lugert granite west of Mt. Sheridan, (Taylor, 1915, p. 21). Locality not stated but all granite in the Mt. Sheridan area is micrographic.
8. Average of 4 micrographic granites (Hamilton, 1959, p. 1120).
9. Average of the 6 micrographic granites.
10. Average of the 7 nonmicrographic and 6 micrographic granites.
11. Average of 4 samples of Carlton rhyolite (table 18, this report).

nent variable. The textural range is from fine-grained and glassy rhyolites to coarse-grained granites, and in the Wichita Province both of these rocks are typically nonmicrographic. By this means it is possible to show that the granophyres of the Wichita Province

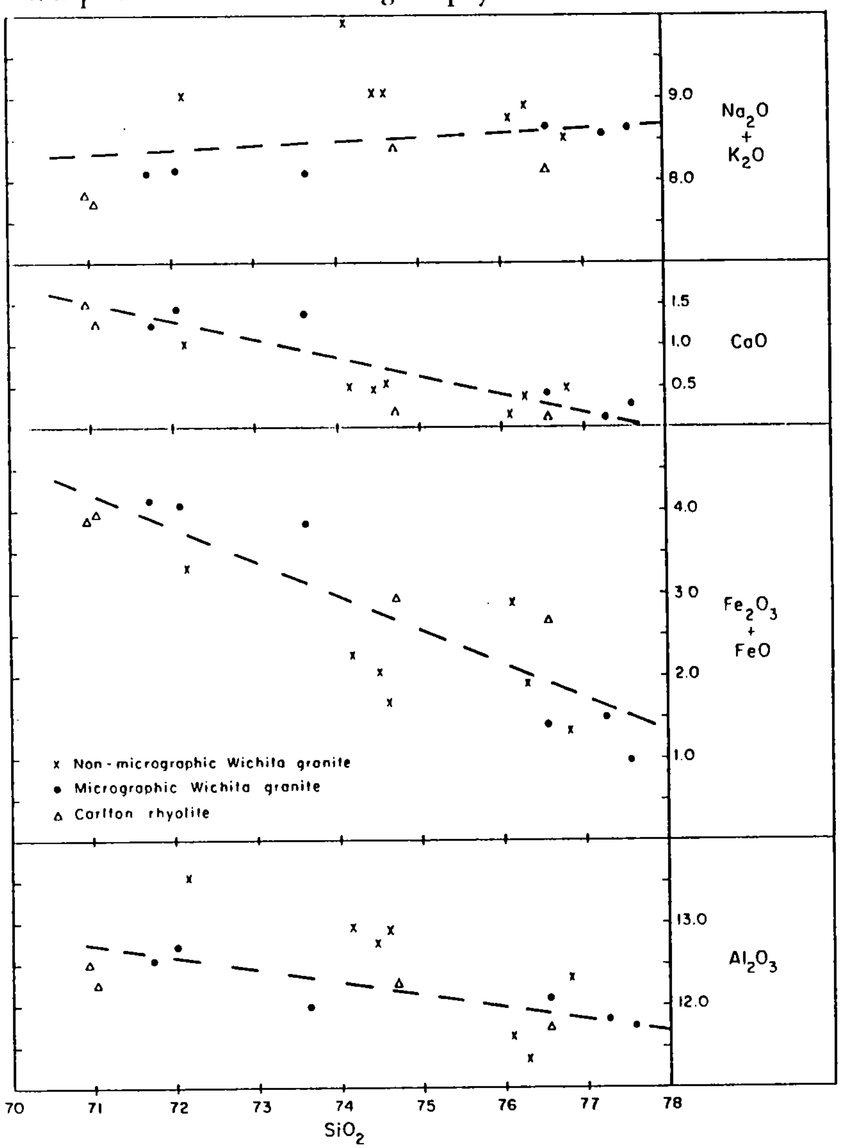

Figure 11. Variation diagrams of Wichita granites and Carlton rhyolite.

are local features that owe their development primarily to a textural environment.

A variation diagram has been made from the analyses of table 10, plotting Al_2O_3, Fe_2O_3+FeO, CaO, and Na_2O+K_2O within the range of 71 to 78 percent SiO_2 (fig. 11). The Al_2O_3, Fe_2O_3+FeO, and CaO increase regularly with decreasing silica, whereas Na_2O+K_2O does not vary significantly. The diagram shows clearly that the plots for normal granite, granophyric granite, and rhyolite are uniformly distributed within the silica range and are about equally spaced with respect to the median line. These three types of rocks are therefore so closely related that they are chemically indistinguishable. They form a continuous differentiation series, having a common line of descent from a single parent magma.

Hamilton, using fewer analyses, published a variation diagram of Wichita granites (1959, p. 1124). His plots are essentially the same as ours, except that he extrapolated into the field containing less than 70 percent SiO_2. Such rocks are known from Duluth and from the Bushveld complex, but in the Wichita Province the presently known limits in silica are between 71 and 78 percent. Within these limits the Wichita granitic and rhyolitic rocks are plotted as nearly straight-line curves and represent closely allied elements of a highly silicic differentiation series.

CHARACTER IN SUBSURFACE

Granite.—Samples of Wichita granite have been obtained from 53 wells in 11 counties of southern Oklahoma (pl. 1). The greatest concentration of data is in Beckham and Greer Counties, in which there are respectively 18 and 12 wells. One or more wells are in Comanche, Cotton, Garvin, Jackson, Jefferson, Kiowa, Murray, Tillman, and Washita Counties. In most wells the penetration of granite is less than 100 feet, but in a few the penetration ranges from approximately 600 to 3,000 feet (table 2). The rocks normally encountered are leucogranites or micrographic leucogranites, occurring as sills and plutons. In outcrops the granites can be subdivided, named, and mapped individually, whereas in the subsurface studies they are described petrographically but are not named.

The subsurface and outcropping granites are alike in being characterized as quartz-feldspar leucogranites. They contain a single perthitic feldspar with little or no free plagioclase, and the femic minerals range from trace amounts to not more than 5 percent. Orthoclase-perthite is the dominant feldspar, although in some wells (Bk-18, Bk-20, Bk-54, and Jk-8) only microcline-perthite is present. Biotite and hornblende are the normal femic minerals, and they are locally accompanied by riebeckite and pyroxene. Accessory minerals are magnetite-ilmenite, fluorite, apatite, and zircon, together with less common epidote, sericite, and sphene.

Plagioclase, in the range of albite to sodic oligoclase, occurs in the cores of perthite crystals, as isolated phenocrysts, and as small intergranular anhedral crystals. Where occurring as phenocrysts, the plagioclase tends to be highly turbid from alteration products, whereas the small intergranular crystals are normally water clear and indistinctly twinned.

Granites of hypidiomorphic granular texture, lacking micrographic intergrowths, are found in about half the control wells. They are especially common in those parts of Beckham, Greer, and Kiowa Counties where Wichita granite is in close proximity to Raggedy Mountain gabbro and is presumably in the lower part of the intrusive granite sheet. Other wells in which this granite occurs are in Jackson and Tillman Counties, wherein the granite intrudes basalt and graywacke. The granite is generally nonporphyritic and has slightly to distinctly coarser grain size than the micrographic varieties. A few of the hypidiomorphic granites contain more plagioclase and mafic minerals than is normal, thus grading toward the two-feldspar assimilation rocks, such as the Cold Springs, that are known in the Wichita Mountains outcrops.

Micrographic granites generally characterize the eastern half of the southern Oklahoma region, occurring in wells of Comanche, Cotton, Jefferson, Garvin, and Murray Counties. The well data indicate for all these occurrences that the granite has the form of sills lying under a roof of rhyolite and upon a floor of basalt or graywacke.

Most of the micrographic granites are at least slightly porphyritic, the phenocrysts being surrounded by a subradial delicate intergrowth of quartz and perthite (pl. XI-2, 3). Also present in many rocks are coarser cuneiform intergrowths. The phenocrysts are dominantly perthite, occurring either as single crystals with a rounded outline or as crystal aggregates. The much scarcer plagioclase phenocrysts are more nearly euhedral. Feldspar phenocrysts have an average size near 3 mm and a maximum size of about 1 cm.

Quartz occurs locally as smaller irregular grains and also as euhedral to highly corroded phenocrysts, although most of it is present in the form of micrographic intergrowth with perthite. The micrographic optic units dominate those rocks in which phenocrysts are rare or absent.

Biotite and common hornblende are the typical femic minerals of primary origin. Riebeckite, the dark blue-green sodium amphibole, is locally a minor constituent yet is characteristic of several subsurface areas. It occurs as equigranular to acicular crystals, either in association with biotite and hornblende or as the only mafic mineral in the rock.

The accessory minerals—iron ore, zircon, apatite, fluorite, and sphene—are generally concentrated in clotted masses with femic minerals. Zircon and apatite in particular are closely associated with clots of iron ore. Part of the iron ore is distinctly titaniferous and is rimmed by finely granular sphene. Zircon occurs also in biotite, and apatite is found as discrete needlelike prisms in perthite and with zircon.

Alteration of feldspars in the Wichita granites is similar to that in the Carlton rhyolite. The main alteration is a clouding of the feldspars accompanied by the formation of finely disseminated hematite, which imparts a distinctive pink color. Commonly called "kaolinization," the clouding appears rather to be due to the presence of numerous tiny vacuoles and probably is of deuteric origin, for the clouding is completely homogeneous and the rocks in most subsurface localities have not been weathered by exposure at the surface. Undoubtedly the most common alteration product of the feldspars is sericite. It occurs in the form of unoriented shreds and is localized particularly in the cores of feldspar crystals and phenocrysts. The sericite is believed to have been formed deuterically. Also found in lesser abundance are epidote, clay minerals, calcite, and zeolites, which replace the feldspars as irregular grains. Both plagioclase and perthite appear to be altered similarly but not necessarily to the same degree.

Primary biotite and hornblende are replaced extensively by chlorite. In biotite the replacement process begins at the outer edges and continues inward; the final stage is a chlorite pseudomorph after biotite. If the biotite is titaniferous, granular sphene is developed within the chlorite layers. Hornblende, in addition to being replaced by chlorite, is locally replaced by secondary biotite. In most occurrences the chlorite appears as finely disseminated shreds, as fibrous mats, or as veins. More than one variety of chlorite is present in some rocks.

Calcite as a vein and replacement mineral is not uncommon. The origin of this carbonate is not known, but it is the youngest mineral in the Wichita granites and may have been introduced from the overlying sediments.

The character of the alterations as described above is essentially the same for surface and subsurface granites. Especially in subsurface is it noticeable that samples at the top of the granite are no different from those drilled more than 1,000 feet below the top, and accordingly little if any of the alteration can be ascribed to weathering processes.

Diabase.—Rocks of diabasic composition and texture occur as dikes that cut Wichita granite in many areas of the Wichita Mountains, and the same kinds of rocks are widely distributed in subsurface. The number of wells in which diabase has been found is unexpectedly large. Five wells in southwestern Oklahoma, abandoned after drilling the top 20 feet or more of basement rock beneath

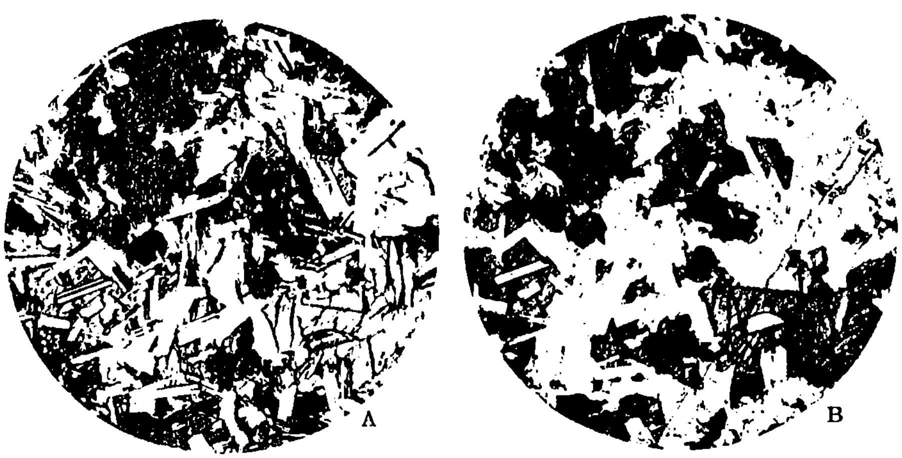

Figure 12. Photomicrographs of diabase.
A. Olivine diabase, Tennessee Gas 1 Kinney, SW¼ SW¼ SW¼ sec. 23, T. 4 N., R. 21 W., depth 2,191-2,220 feet. Fresh titaniferous augite contains laths of plagioclase. Dark granular mineral is fibrous iddingsite after olivine. Locally (not shown) the olivine is essentially unaltered. Diabase cuts Wichita granite in this well. Thin section Jk-1-1. Polarized light. Field diameter: 2.9 mm.
B. Same; ordinary light.

a sedimentary blanket, recovered only diabase. As most wells of this region have been drilled for oil and gas, in part guided by geophysical surveys, it is not unreasonable that, because of their density and magnetic character, subsurface diabase bodies have produced local anomalies on the basis of which wells were located and drilled.

The diabases are invariably composed of plagioclase, pyroxene or its alteration products, and iron ore. Some of them also carry olivine as a major rock-forming mineral. Hornblende, biotite, and apatite are the only other common primary minerals. Chlorite, iddingsite, calcite, feldspar alterations, biotite, amphibole, sphene, and quartz are present as alteration or replacement minerals.

Plagioclase and pyroxene are the two most important minerals, occurring in subequal amounts. The plagioclase is calcic andesine or sodic to intermediate labradorite. Subhedral or euhedral laths of plagioclase are generally set in the pyroxene (fig. 12), giving a subophitic to ophitic texture. The pyroxene is commonly pigeonitic or diopsidic augite, but other types are known, and more than one type occurs in a single rock. Locally the pyroxene is distinctly titaniferous. The iron ore, a titaniferous magnetite, is found as granules, irregular intergranular crystals, skeletal crystals, and as schiller-texture inclusions within the pyroxene.

Olivine is normally found as rounded granules, either discrete or in groups. Iddingsite commonly replaces all or part of the olivine. This alteration is locally so selective that the olivine is severely altered, yet the remaining constituents of the rock are amazingly fresh.

Navajoe Mountain Basalt-Spilite Group

INTRODUCTION

Extrusive rocks of basaltic, spilitic, and andesitic composition are widely distributed in the Wichita Province of southwestern Oklahoma. Unlike the rhyolites, granites, and gabbros which crop out in the Wichita Mountains, the basic and intermediate flow rocks are known only in subsurface. Penetrated in 11 wells distributed over five counties, the flows are known to occur in two principal areas. One consists of a discontinuous belt along the south flank of the Wichita Mountains (pl. I), where the basaltic tracts are remnants of a formerly thick series intruded by granites but now largely eroded away. No basalt has been found by drilling south of this belt, in southern Tillman County, and none has been found in the central part of the Wichita uplift. In both areas the basalt is inferred to have been present but has been removed by erosion following uplift in pre-Carlton time.

The second and presumably much larger area is on the north flank of the Wichita Mountains, where, preserved beneath a thick cover of Carlton rhyolite, the basalts are known in five wells and have a maximum drilled thickness of 1,049 feet. They are believed to extend throughout much of the Southern Oklahoma geosyncline, but as yet no well has been drilled deep enough to penetrate them in the deeply downfolded areas of this region. The basaltic rocks probably were laid down in a marine environment, and they are an integral part of the sediments and flows that constitute the first stage of filling of the geosyncline.

The basaltic sequence is here named the Navajoe Mountain Basalt-Spilite Group, referring to those flow rocks which are prominent within it. The name is taken from Navajoe Mountain (pronounced Nav-ah-hoe), a locally well-known hill of Wichita granite in the eastern part of Jackson County. Here the granite has been intruded through the central part of the southern basaltic belt. Basaltic rocks do not crop out at this locality, but dark-green biotite-rich hornfels derived from basalt occurs abundantly as inclusions in the granite. The best exposures are in a quarry opened by the Youngman Construction Company for the production of crushed stone at the south end of Navajoe Mountain, NE¼ SW¼ sec. 1, T. 2 N., R. 19 W.

Present knowledge about thickness and composition of the Navajoe Mountain Group is derived mainly from relatively thick penetrations in two wells immediately northwest of Navajoe Mountain (Jk-4, Jk-7), and from a single well (Cm-1) on the north flank of the Wichita Mountains. In these three wells the drilled thickness of basaltic rocks ranges from 819 to 1,049 feet. Although the base has not been penetrated in any well and the full thickness of the group is therefore unknown, the probable thickness is judged from geophysical evidence to be several thousand feet. Andesite, meta-basalt, and basic hornfels characterize the Navajoe Mountain Group in the southern belt, whereas basalt, spilite, altered palagonite tuff, and thin interbedded sediments are typical of the northern belt. The most significant well is without doubt the Stanolind 1 Perdasofpy (Cm-1), in which basalts, spilites, and tuffs more than 1,000 feet thick occur beneath Carlton rhyolite, the basaltic rocks being separated from rhyolite by a 600-foot sill of Wichita granite (pl. III). Because critical information on original rock composition, thickness, stratigraphic position, and intrusive relations is supplied by this well, it is designated the type well for the Navajoe Mountain Group.

AGE AND SIGNIFICANCE

Rhyolites, basalts, and meta-graywackes compose the framework sequence of sediments and flows in the Wichita Province, and within this sequence the Navajoe Mountain Basalt-Spilite Group occupies a medial stratigraphic position. That the basalts are overlain by thick rhyolitic flows and tuffs of the Carlton Group is shown by drilling in wells Cm-1 and St-1, along the north flank of Wichita Mountains. Most of the rhyolite has been removed by erosion on the south flank, however, and stratigraphic relations in that region are not clearly shown.

Underneath the Navajoe Mountain basalt are graywackes and sandstones of the Tillman Metasedimentary Group. No well has been drilled through the full thickness of basalts and into thick underlying graywacke, yet in one well (Cm-1) graywacke is thinly interstratified with altered palagonite tuffs nearly 1,000 feet below the top of the Navajoe Mountain Group. If this well had been deepened, it doubtless would have penetrated the principal graywacke sequence.

The probable widespread occurrence of graywacke below basalt is even more strongly indicated by the subsurface mapping in Jackson and Tillman Counties (pl. I), where rocks of the Tillman Group are in contact with basalts and must dip beneath them to satisfy the mapped relations. Moreover, rocks of the Tillman Group are the oldest of the Wichita Province. They are not known by drilling to contain basalt, and they are coextensive with meta-graywacke near Red River in north Texas (pl. V), where they are the oldest rocks lying upon the Precambrian granites of the central continental craton.

At numerous localities the basaltic rocks are intruded by Wichita granite. A sill of granite 600 feet thick lies between basalt and rhyolite in the Stanolind 1 Perdasofpy (well Cm-1), and in four other wells the basalts have been moderately to thoroughly reconstituted by granite intrusion, yielding metabasalts and basic hornfels. The area of maximum reconstitution is on the south flank of the Wichita uplift (table 11), where plutons of Wichita granite have been injected into and through the basaltic rocks. All these relations show that the Navajoe Mountain Group is older than Wichita granite.

Time relations of the basalt group to the Raggedy Mountain gabbro are not directly known from field occurrences, as the two rocks are not in contact except in one subsurface area of northern Tillman and southern Kiowa Counties, where they are in contact but are interpreted to be separated by a fault. The basalts, spilites, andesites, and basaltic tuffs of the Navajoe Mountain Group are the only extrusive rocks of basic composition known in southern Oklahoma, and they are judged to be effusive equivalents of the same magma that consolidated at depth to form gabbro and diorite of the Raggedy Mountain Group.

No isotopic age determinations have been made on minerals in the basaltic rocks. Indeed, the biotite and hornblende sparsely present in the least altered samples are so altered that they would be unsuitable for age determination, and furthermore these minerals may have originated in part at the time of granite intrusion. In the absence of age dating the geologic relations are emphasized—the Navajoe Mountain Basalt-Spilite Group is correlated in time of origin with the Raggedy Mountain Gabbro Group and is assigned an Early Cambrian(?) age.

One type of rock in the basaltic group is spilite, an albite basalt, which has special significance in geologic interpretation. After reviewing the occurrences, associations, and problems of spilitic rocks in many parts of the world, Turner and Verhoogen (1960, p. 258, 261) stated:

> Most eroded geosynclines show evidence of igneous activity approximately synchronous with at least the later part of the filling and sinking of the trough. Prominent among the products of such activity, and almost confined to the geosynclinal environment, are submarine lavas, tuffs, and equivalent intrusives of sodic composition. These constitute the spilite keratophyre association. . . . From the characteristically close association of spilitic rocks with marine sediments, and from the prevalence of pillow structure among typical spilites, it is clear that these are mostly submarine lavas poured out on the sea floor or injected into unconsolidated sediments. It is equally obvious from the great thickness of associated arkosic sandstones and graywackes consistently

TABLE 11.—LIST OF WELLS DRILLED INTO ROCKS OF THE NAVAJOE MOUNTAIN GROUP

	Well no	*Company and farm*	*Location*	*Depth in feet*	*Apparent thickness drilled*	*Rock type*
North flank Wichita uplift	Cm-1	Stanolind No. 1 Perdasofpy	SE NW SW 11-4N-12W Comanche Co.	8.625-9.674	1.049′	Spilite, basalt, and palagonite tuff
	St-1	Carter No. 1 Williford	C SE NE 24-2N-9W Stephens Co.	9.810-10.149	339′	Spilite
	Kw-19	Baker No. 1 Copeley	NW NE SE 30-7N-17W Kiowa Co.	1.268-1.289	21′	Basalt
	Kw-75	Lewis No. 1 Coakley	SE NE SE 30-7N-17W Kiowa Co.	1,250-1,282	32′	Basalt
	Kw-66	Pearson No. 1 Folks	SE SW NW 32-7N-17W Kiowa Co.	1.640-1,832	192′	Andesite
South flank Wichita uplift	Jk-4	McCasland-Wilcox No. 1 Edwards	NW NW NE 9-3N-21W Jackson Co.	3.594-4,413	819′	Andesite
	Jk-7	Lippert No. 1 Howard	SW NW 10-3N-19W Jackson Co.	840-1,675	835′	Basic Hornfels
	Jk-18	Sun No. 1 Wilson	NE NE SE 23-1N-20W Jackson Co.	3,694-3,727	33′	Metabasalt
	Kw-49	Young No. 1 Cook	NE NE NW 33-2N-16W Kiowa Co.	662-677	5′	Basic Hornfels
	Ti-15	Buel and Herdon No. 1 Haught	SE SE NE 22-1N-16W Tillman Co.	790-841	51′	Metabasalt
	Cm-30	Frankfort No. 1 Poaf-Py-Bitty	SW SW SW 4-1S-11W Comanche Co.	7,200-7.230	30′	Spilite(?)

present, that volcanic activity of this type occurs during the development and slow sinking of geosynclines or unstable basins.

The association in southern Oklahoma of spilitic rocks of the Navajoe Mountain Group with graywackes of the Tillman Group fits well into this general scheme. The spilites and graywackes alike probably are marine in origin and are part of a geosynclinal sequence.

The marine environment of spilite and graywacke is to be contrasted with that of the younger Carlton Rhyolite Group, which was extruded entirely as a thick sequence of subaerial flows and nonmarine tuffs. The marine early phase of geosynclinal filling is considered to be represented by deposition of graywacke followed by the outpouring of basaltic and spilitic lavas, whereas the later stage is represented by the extrusion of nonmarine rhyolites.

Several converging lines of evidence show that an unconformity probably separates marine basalt from nonmarine rhyolite. The change in depositional environment alone is suggestive of an unconformity, but the conclusion is strengthened by the striking differences in structural and stratigraphic relations of rocks drilled in the Perdasofpy well (Cm-1) as compared with outcropping rocks in the Mt. Scott area, only 6 miles away. Wichita granite, intruded as a sill below rhyolite and above basalt in the well, is intruded as a sill below rhyolite and above gabbro on the outcrop. The basalt formerly present in the outcrop area was eroded away as a result of uplift before the outpouring of rhyolite lavas. The uplift was so great that all basalt, together with an unknown thickness of underlying rock, probably Tillman graywacke, was eroded away and the coarse-textured underlying gabbro was exposed. Rhyolite was extruded upon the eroded gabbro surface, and granite later was injected in the form of a sill between these two rocks. Because the basalts are preserved in the area of the Perdasofpy well and are more than 1,000 feet thick at that locality, they could not have participated in the uplift of the Mt. Scott area. A pre-rhyolite fault with at least one mile of throw is indicated between the two areas, and the inferred relations are shown graphically in plate IV, panels W-3, -4, -5, and -6.

The proposed unconformity between rhyolite and basalt separates the time of formation of Carlton rhyolite and Wichita granite

from the time of formation of Navajoe Mountain basalt, Raggedy Mountain gabbro, and Tillman graywacke. The younger silicic rocks, isotopically dated at 525±25 million years and therefore probably of Middle Cambrian age, are thus set apart by a period of uplift and erosion from the basic rocks and graywackes of the early geosynclinal stage. The two available isotopic ages from rocks of the early stage are from biotite in Raggedy Mountain gabbro and diorite (table 4). The Rb/Sr and K/Ar age dates are 20 to 30 million years older than biotite from the Wichita granite, indicating that the rocks of the early stage are approximately 535 to 550 million years, or of Early Cambrian age. The unconformity is thus placed at the time division between two major epochs and between two contrasting kindreds of rocks.

PETROGRAPHY

The Navajoe Mountain Group is composed dominantly of basaltic, spilitic, and andesitic flows. Tuffs containing devitrified basaltic glass, with interstratified thin beds of tuffaceous graywacke, are sparsely present in the known occurrences. Also included within the group are basic hornfelses derived from these extrusive rocks where they have been intruded by plutons of granite.

Basalt and spilite are the more abundant rock types. In the deepest penetration of this group, Stanolind 1 Perdasofpy (well Cm-1), they are interlayered through a thickness of 900 feet, and either basalt or spilite was found in most of the other wells of lesser penetration (table 11). Andesite alone was found in two wells, in one of which it was penetrated through a thickness of 819 feet. Altered palagonite tuffs have a drilled thickness of 150 feet in well Cm-1, occurring beneath thick basalts and spilites. Although basaltic tuffs have not been found in other wells, they probably occur and are widely distributed in the undrilled parts of the Navajoe Mountain Group.

All the rocks of the group show various degrees of alteration to chlorite, calcite, epidote, zeolites, and sphene, and some of them are slightly to moderately silicified. The common flow rocks have nonporphyritic plagioclase laths set ophitically in pyroxene. A few of the basalts and andesites are porphyritic. Vesicular structure, filled amygdules, and flow fabric as shown by subparallel alignment of feldspars are sparsely yet conspicuously developed in some samples.

Basalt and spilite.—The basalts and spilites are so similar in grain size, color, and texture that they are indistinguishable except through petrographic examination of thin sections. Generally non-porphyritic, both are characterized by divergent plagioclase laths 0.2 to 0.3 mm long, surrounded ophitically by pyroxene (pl. XII-1, 2). Plagioclase of the basalt is normally labradorite showing well-developed polysynthetic twins, whereas in spilites the plagioclase is albite. Universal-stage determinations of four spilite samples from wells Cm-1, Cm-30, and St-1 show a constant composition of An_{8-9}. Much of this albite is poorly twinned and is extensively but variably altered. Simple zeolitic clouding, or replacement by chlorite, sphene-leucoxene, and epidote, are the more common alteration products. The alteration is so selective in some albite laths that one crystallographic orientation is clouded whereas its twin is clear.

Other than plagioclase and pyroxene, the principal constituents of the basalts and spilites are chlorite, iron ores, uralitic hornblende, brown biotite, sphene-leucoxene, calcite, epidote, quartz, and zeolites. The iron ores and at least part of the biotite are primary, but the other minerals are either autometamorphic in origin or represent a beginning stage of regional metamorphism. The degree of alteration, particularly in the relative abundance of chlorite and pyroxene, is highly erratic. Some samples contain fresh pyroxene with only a thin halo of chlorite, but in others that are intensely altered, a fine-grained mosaic dominated by chlorite replaces all pyroxene and also much of the feldspar. Cutting chips of both types are found in the same sample.

Alteration in the spilitic rocks generally is more advanced than in the basalts. Chlorite and granular sphene-leucoxene are especially prominent in the spilites, as are veins and amygdules of albite, chlorite, calcite, prehnite, epidote, and chalcedony. A chemical analysis of the best sample available, a core from the Carter 1 Williford (well St-1) is given in table 18. It contains approximately 50 percent albite (An_9) and its alteration products, 35 percent chlorite, and 15 percent sphene and leucoxene. Despite the alteration, the spilitic nature of the sample is shown by its content of 3.98 percent Na_2O, 46.27 SiO_2, 10.84 FeO, and 3.72 TiO_2, which compare respectively with 4.93, 51.22, 9.20, and 3.32 percent in the average spilite of other regions (Turner and Verhoogen, 1960, table 25, p. 262). Another spilitic rock that is only partly altered occurs in the Frankfort 1 Poaf-Py-Bitty (well Cm-30). It contains 42 percent albite (An_8) and 25 percent uralitic amphibole, with subequal amounts of epidote, chlorite, calcite, and sphene.

Much of the basalt of the Navajoe Mountain Group is altered. In addition to the thick penetration of altered basalts in the Perdasofpy well (Cm-1), similar basalt was found in wells Kw-19 and Kw-75 on the north flank of the Wichita Mountains. Basalt in the Lewis 1 Coakley (well Kw-75) shows relict plagioclase phenocrysts in subparallel alignment. The rock is cut by Wichita granite and most of its components are thoroughly altered to sericite, biotite, chlorite, and calcite. On the south flank of the mountains the basalt normally is porphyritic and contains plagioclase phenocrysts as much as 2.5 mm long. Wells Jk-18 and Ti-15 cut this type of rock. In well Ti-15, Buel and Herdon 1 Haught, phenocrysts of labradorite (An_{58}) are set in a biotite-iron ore-chlorite-calcite groundmass. Some albite also is present, indicating incipient formation of a spilitic rock. Less altered cuttings from the Herdon well have groundmasses composed of iron ores, pyroxene, hornblende, biotite, chlorite, and quartz.

Several lines of evidence indicate that some or perhaps all of the southern Oklahoma spilites are albitized basalts. Part of the albite can be shown to be of secondary origin. It occurs both in the form of veins and amygdaloidal fillings, locally with epidote, and as discontinuous masses of optically continuous albite that has replaced divergent clusters of labradorite. The interlayering of spilites with basalts through a thickness of 900 feet in the Perdasofpy well shows that albite does not characterize all the basic flows of a single sequence at a single locality, and suggests that it was introduced after the flows were laid down. Regardless of its origin, however, the albite is believed to be genetically related to a marine environment and to have derived its sodium from sea water or connate fluids, or from the associated graywackes.

Basaltic tuffs.—Altered palagonite tuffs underlie the basalt-spilite sequence of the Perdasofpy well through a drilled thickness of 150 feet. The deep drilling of this well has been especially valuable in providing information on the basaltic tuffs, for none was found in other wells drilled into the Navajoe Mountain Group in southern Oklahoma.

Among the cuttings are scoriaceous black glassy fragments which proved to be devitrified basaltic glass with undulose extinction and anomalous optical properties (pl. XII-3). These glass fragments are golden to olive green, homogeneous in appearance, and in part nearly isotropic. They contain numerous oval to round amygdules filled with radial fibrous chlorite. Fragments of nearly black basalt, exhibiting a pilotaxitic texture, also are present. Other detritus consists of well-crystallized basalt containing fresh pyroxene with ophitically enclosed plagioclase laths. Large sericitized plagioclase fragments are the remaining pyroclastic constituents. Chlorite and zeolites, mainly chabazite and analcime, occur in the form of filled amygdules and interclastic material. Prehnite, plagioclase, calcite, chalcedony, quartz, and epidote are present as amygdule fillings. They are abundant in some parts of the drilled sequence.

Thinly layered fine-grained detritus is interstratified with normal coarse-textured palagonite tuff. Although thickness of the fine-grained sediments is difficult to determine from cuttings, most of the beds are judged to be less than 20 feet, and their total thickness in the pyroclastic rocks probably is slight. The sedimentary beds are mostly tuffaceous graywacke consisting of diverse lithic and crystal fragments set in a clay-mica matrix. The matrix is virtually unreconstituted. Sand-sized lithic fragments are mainly basalt, but fragments of felsitic rhyolite and spherulitic rhyolite also were observed. The mineral detritus is quartz, perthite, and plagioclase. From this composition it is clear that rhyolites were locally available as a source of sedimentary material, in a terrane that was dominantly basaltic.

The occurrence of graywackes in the Perdasofpy well is significant in showing a transition between the basaltic group and the Tillman Group, which is widely distributed south of the Wichita Mountains but has not been penetrated by drilling north of the mountains.

Andesite.—Closely allied to the basalts are flows of andesite. Locally they are known to be thick, and to be the sole representatives of the Navajoe Mountain Group. One important penetration is in the Pearson 1 Folks well (Kw-66), in which the rock is holocrystalline nonporphyritic pyroxene-biotite andesite. The plagioclase is andesine (An_{40}), as determined by the universal stage. Coarse cuttings show the rock to be vesicular and to contain euhedral milky

analcime in some of the vesicles. The bulk of the rock is only slightly altered to chlorite.

The thickest penetration of andesite in southern Oklahoma—819 feet—is in the McCasland and Wilcox 1 Edwards (well Jk-4). In its uppermost part the andesite is mildly porphyritic and contains phenocrysts of augite and andesine (An_{32}). The groundmass, although altered and high in iron oxides, is composed largely of plagioclase laths in a subtrachytic alignment (pl. XII-4). Chlorite and pale-green amphibole replace augite phenocrysts irregularly, and quartz replaces portions of the groundmass. Modal and chemical analyses of this rock are given in table 18. It contains 56.42 percent SiO_2, 0.73 TiO_2, 4.77 FeO, and 2.14 Na_2O, thereby contrasting markedly with the spilites in having greater SiO_2 and appreciably less TiO_2, FeO, and Na_2O.

Andesite in the middle part of the drilled sequence is strongly porphyritic, containing roughly one-third modal phenocrysts of zoned andesine set in an extremely fine-grained groundmass of plagioclase, chlorite, iron ores, sphene-leucoxene, and introduced chertose quartz. Chlorite has completly replaced femic phenocrysts (augite?). Epidote is present as veins and small cavitylike fillings.

At the bottom of the well is highly altered andesite. Only relict patches occur, the remaining rock being composed of quartz and sericite with minor iron ore grains, chlorite and crystals of riebeckite. The occurrence of riebeckite, even in small amounts, suggests that the solutions altering the andesite were of granitic origin.

Basic hornfels.—In the region south of the Wichita Mountains, rocks of the Navajoe Mountain Group are intruded by cross-cutting bodies of Wichita granite. In the area of Navajoe Mountain the granite has apparently erupted through the basaltic sequence, dividing the linear basaltic band into two separated segments (pl. I). Two wells drilled near the intrusive contact penetrated medium-rank to high-rank basic hornfels. The character and extent of the intrusive reaction are shown best by samples from the Lippert 1 Howard (well Jk-7), wherein 835 feet of hornfels and intrusive granite was drilled. The rock is fully crystalloblastic, but shows locally a slight schistosity by crude alignment of prismatic hornblende and platy biotite (pl. XII-6). Anhedral grains of magnetite and plagioclase, mostly untwinned, are present in all samples and occur with pyroxene-hornblende, pyroxene-biotite, or hornblende-biotite associations.

The pyroxene is diopside. The rock grades in metamorphic rank from the upper hornblende hornfels facies to the lower pyroxene hornfels facies containing the typical assemblage plagioclase-hornblende-diopside (-biotite) (Fyfe and others, 1958, p. 211). Average grain size of minerals in the hornfels is 0.05 mm, but ranges widely from 0.01 to 0.3 mm. The larger grains are imperfectly formed and strongly sieved prisms of hornblende.

Wichita granite intrudes the hornfels in the Howard well. Four of the six thin sections made from samples in this well contain individual chips of granite, or single chips that show the contact between hornfels and granite, or an intimate migmatic mixture, leaving little doubt that granite extensively cuts the host rock and is responsible for its metamorphism.

The Young 1 Cook (well Kw-49) also penetrated hornfels, although only five feet was drilled. Crystalloblastic pyroxene, magnetite, and plagioclase, together with lesser biotite, quartz, and tremolitic amphibole, characterize the rock. The presence of about 25 percent pyroxene indicates high metamorphic rank, which is presumed to result from intrusion by Wichita granite at depth below the bottom of the Cook well. Five miles south, in well Ti-15, is low-rank porphyritic basalt containing chlorite, quartz, and calcite showing only mild crystalloblastic reconstitution.

Raggedy Mountain Gabbro Group

INTRODUCTION

A stratiform body of basic igneous rocks is widely distributed in the Wichita Mountains region of southwestern Oklahoma. Its presently known areal dimensions are approximately 110 by 25 miles, and its actual dimensions are inferred to be about 150 by 40 miles. Roughly the uppermost 1,000 feet of the body crops out in the Wichita Mountains, and as much as 8,000 feet has been penetrated in a single well. The layered and laminated rocks are chiefly dial-lage gabbro, anorthosite, olivine gabbro, troctolite, and quartz diorite. All are probably differentiation products of gabbro magma injected concordantly as a lens into graywacke and sandstone of the Tillman Group. Granites of the Wichita Group have been injected extensively into the gabbroic rocks, locally modifying them at intrusive contacts and spreading outward above them in the form of widely distributed sills. Much of the gabbro itself is essentially unaltered, however, even the olivine being preserved as fresh bright-green grains.

The largest outcrop area of gabbroic rocks is in the central part of the Wichita Mountains region, in a low range of hills called the Raggedy Mountains (Taff, 1904, pl. II; p. 56-57). The best exposures and most of the gabbro outcrops of the Raggedy Mountains are in T. 4 N., Rs. 16, 17 W., where they cover an area of about 35 square miles. From these outcrops the name Raggedy Mountain Gabbro Group is taken and is applied to all gabbros and allied rocks of the Wichita Province.

The Raggedy Mountain Gabbro Group comprises the oldest igneous rocks of the Wichita Province. They are older than the 525-million-year granites of the Wichita Group, which everywhere intrude them and, for reasons developed elsewhere in this report, the two groups are believed to be separated by a period of faulting, uplift, and erosion. The basaltic lavas and tuffs of the Navajoe Mountain Group likewise are intruded by Wichita granite, and are considered to be the extrusive equivalents of the gabbros. Isotopic dating of biotite in gabbro and diorite of the Raggedy Mountain Group yields a probable age of about 535 million years (table 4), and the rocks are assigned an Early Cambrian(?) age.

The conspicuous layering of the surface gabbroic rocks and their association locally with granophyres have led earlier writers to propose a lopolithic form for all the Wichita Mountains intrusions. It is here concluded that the gabbros and granites originated separately. The gabbro body is lopolithic in the sense that it is layered and probably has the form of a lens, but the younger granite is not genetically related to it and is not a part of the lopolithic body.

SURFACE STUDIES

Mapping by Taff (1904), Taylor (1915), Hoffman (1930), Chase (1950b), and Merritt (1958) has demonstrated the occurrence of gabbroic rocks in three principal areas of the Wichita Mountains.

The largest area is that of the Raggedy Mountains, in the central part of the Wichita Mountains outcrops, where a northwestward-trending low range of gabbro hills 20 miles long and 6 miles wide projects upward through a cover of flat-lying Permian redbeds.

Outlying hills of Wichita granite encircle the gabbro outcrops on the south, west, and north. Hunter (1962) and his students (Gilbert, 1960; Spencer, 1961) have shown that the gabbroic rocks of this area consist of three mappable units, each of which contains stratiform layers of troctolite, anorthosite, anorthositic gabbro, and olivine gabbro. The rocks display rhythmic layering as well as igneous laminations, and they are interpreted as originating by differentiation and gravity settling within a chamber.

Chemical and modal analyses of typical gabbro and anorthosite from the Raggedy Mountains are given in table 18.

Eastward from the Raggedy Mountains, in northwestern Comanche County, the gabbroic rocks pass beneath high hills of Wichita granite and are covered, except in two valley areas where the overlying granite has been eroded away. The northern area of exposure is along the northeast flank of the Wichita Mountains, and here, in an outcrop belt 12 miles long and 2 miles wide, gabbro and diorite are capped by a sill of granite that has been differentially eroded to form the peaks of Mt. Scott, Mt. Sheridan, and Tarbone Mountain. The contact of gabbro or diorite with granite, as well as the southwestward dip of the contact surface, can be mapped along the slopes

Figure 13. Polished surface of anorthosite from Raggedy Mountain Group showing pronounced planar orientation of plagioclase crystals, x2.1. Valley of Medicine Creek northwest of Mt. Sheridan, NE¼ NE¼ NW¼ sec. 6, T. 3 N., R. 13 W.

of these mountains. Beneath the diorite is diallage gabbro and anorthosite showing well-developed planar orientation of plagioclase (fig. 13). The gabbro in particular is noteworthy for containing large inclusions of Meers Quartzite (Hoffman, 1930, p. 31; Merritt, 1948), which is here considered to be a part of the Tillman Metasedimentary Group. Being the principal area of the Wichita Mountains where such inclusions are found in gabbro, it is of great value in showing the metasedimentary character of the host rocks into which the gabbro magma was intruded.

The third and smallest exposure of Raggedy Mountain gabbro in the Wichita Mountains is along the floor of a valley that is surrounded by granite hills. The outcrops lie chiefly in T. 3 N., R. 14 W., and are clearly the southeastward extension of the gabbroic rocks in the Raggedy Mountains (pl. 1). Most of the rock in this area is anorthosite, in part conspicuously layered.

Intrusive relations of granite into gabbro are evident at many localities and have been noted by all earlier workers. Inclusions of gabbro are widely present in granite rocks of the Wichita Mountains; granite of the Cold Springs area in T. 4 N., R. 17 W., has been extensively and irregularly injected into microdiorite and still older gabbro, producing a variety of hybrid rocks (Walper, 1951); the gabbro itself has been modified locally at or near intrusive contacts (Huang, 1955); and, finally, the great sheetlike body of granite normally overlying the gabbro body exhibits on a regional scale certain cross-cutting relations that demonstrate a nonconformable contact between them. The layered gabbros do not grade upward into granite, but instead are truncated by the granite in such a way that granite rests at different localities upon diorite, diallage gabbro, anorthosite, or troctolite. Over a large area in subsurface granite also lies above diorite and quartz diorite.

That the Raggedy Mountain Gabbro Group is overlain by a thick sheet of younger granite can be observed directly in the eastern one-third of the outcrop region. Elsewhere these relations cannot be proved but can be reasonably inferred. In the western one-third of the region (Lake Altus area, Merritt, 1958, pl. I) granite comprises about 98 percent of the hills that rise above the Permian redbed plain, yet low on the slopes of Soldier's Spring Mountain, Dome Mountain and vicinity, and Mount Powwow are small areas of gabbro and anorthosite. These rocks represent either the upper part of the gabbro body, in which case the gabbro-granite contact is barely concealed beneath the surface exposures, or else they are large gabbroic xenoliths which were caught up in the rising granite magma. In either case, gabbro is presumed to underlie granite at shallow depth throughout much of the Lake Altus area.

Between the granites of the Lake Altus or western area and the granites of the eastern area is the elongate belt of gabbro hills in the Raggedy Mountains. Although no granite caps the gabbro of the Raggedy Mountains, it is virtually encircled by hills of the younger granite (pl. I). To a structural geologist this is a clearly defined example of anticlinal uplift, erosion, and exposure of the oldest or gabbroic rocks in the axial part of the fold. Not only have the overlying granites been removed by erosion, but it can be inferred that the central Raggedy Mountains area is the locus of greatest structural uplift in the Wichita Mountains system.

The superposition of granite upon a layered body of gabbro, especially as exemplified by the remarkably good exposures in the eastern area near Mount Sheridan, has given rise to the concept that the igneous rocks of the Wichita Mountains have originated as a lopolith. Hoffman (1930, p. 46, 47) first called attention to the close resemblance of the Wichita Mountains rocks to sills and lopoliths of British Columbia, Montana, and Minnesota; and Hamilton (1956, 1959) enlarged the comparison to show some similarities to the Duluth lopolith and the Bushveld complex. From a knowledge of the surface geology it is evident that the gabbro magma was injected into an elongate chamber under structurally quiescent conditions permitting gravity differentiation on a major scale. Whether the floor of the sill-like body is centrally sunken, as required for a lopolith, cannot be demonstrated from surface exposures or from subsurface drilling, but it is certain that the central part of the gabbro body now marks the axis of greatest structural uplift in southwestern Oklahoma and the Texas Panhandle. The origin of the granite as a directly superposed differentiation product of the gabbro magma also can be strongly disputed, for it can be shown that the granite cuts across and is definitely younger than the gabbro.

SUBSURFACE FORM AND DISTRIBUTION

Study of the Raggedy Mountain Gabbro Group in subsurface confirms the layered character of the gabbro and the widespread

occurrence of an overlying sheet of granite, and defines more precisely the distribution, form, and thickness of the gabbro body.

Samples have been examined from 27 wells drilled into gabbroic rock in five counties of southwestern Oklahoma. All but three of the wells are located along the northwestward-trending deeply eroded axis of the Wichita Mountains system, which extends from the outcrops of the Raggedy Mountains into northwestern Kiowa County, northern Greer County, southwestern Washita County, and southern Beckham County (pls. I, II). As mapped in this area the gabbro has a subcrop width, beneath Permian strata, of ½ mile to 2 miles, and is flanked on both sides by Wichita granite. The pattern of subsurface rock distribution is that of an elongate anticlinal fold, from the top of which the younger granite sheet has been eroded. In the Oklahoma part of the anticlinal fold the length of the gabbro body is 90 miles, and from the work of Flawn (1956) it can be continued 20 miles into the Texas Panhandle, for a total known length of 110 miles (pl. V). Wichita granite probably overlies gabbro in Texas, as it does in Oklahoma, and extends slightly beyond the gabbro subcrop (plate V).

A second and much smaller subsurface area of gabbro is delineated by three wells drilled south of the Wichita Mountains axis, in the southernmost part of Kiowa County and the northernmost part of Tillman County (pl. I). It is an outlying segment of the Raggedy Mountain Gabbro Group, probably brought near the surface by pre-Permian faulting, and stripped of its overlying granite by erosion. Combined with the principal belt, the southern area gives to the gabbro body a width of 25 miles, the maximum known for the region.

In several wells the repeated interlayering of gabbroic types is clearly shown, and the rocks penetrated over much of the region are identical to those exposed in the Wichita Mountains. Slightly more than 8,000 feet of Raggedy Mountain gabbro has been drilled in a single well, without encountering any exceptional rock (such as dunite) and without reaching the base of the gabbro body. Although the lower part and total thickness of the layered gabbro thus are unknown, the minimum thickness of the intrusive body in the area of the drilled well may be taken as approximately 8,000 feet.

Along the axis of the Wichita Mountains system gabbro is in contact only with granite, whereas in the southern area gabbro also is in contact with basalt and with metasediments. In the southern area, granite outcrops are present immediately north of the gabbro and doubtless are in their normally overlying position. The gabbro-basalt contact on the east is interpreted as a fault because the intrusive gabbro was emplaced at depth and was never in original contact with the extrusive basalt. On the south, where gabbro is bordered by graywacke of the Tillman Metasedimentary Group, the contact relations are in doubt. The favored interpretation is that gabbro has intruded graywacke and that the fine-grained texture of the gabbro in well Ti-38 indicates proximity to the lateral margin of the intrusive body. Under this interpretation the gabbro body extends southward into the graywacke sequence and disappears a short distance beyond the mapped contact.

The northern and eastern limits of Raggedy Mountain gabbro can be roughly inferred from structural relations. Where gabbro is present and is known to be thick, the structural pattern is characterized by gentle folding and block faulting, as exemplified in the Wichita uplift. Structural segments bordering the Wichita uplift on the north and east are the Anadarko, Marietta, and Ardmore basins (pl. II). In them the intensity of folding of the basement-rock surface is so great, and is so sharply in contrast with the folding of the Wichita uplift, than any gabbro in these basins must be in the form of a sheet that is too thin to hinder the development of close folding. Indeed, the gabbro body probably disappears as a narrowly tapering wedge within the basin flanks, a short distance away from the margins of the Wichita Mountains.

In summary, the actual dimensions of the gabbro body are probably not much greater than those presently known. The width appears to be approximately 40 miles, and the length, although more conjectural, is about 150 miles. The massive, gently folded horst of the Wichita uplift is believed to coincide approximately with the major part of the gabbro body, the gabbro acting in fact as the massive stabilizing element in the formation of the horst. Total thickness of the gabbro may be no more than 10,000 to 12,000 feet, as the 8,000-foot thickness was penetrated near the axis of greatest uplift and therefore probably near the thickest part of the gabbro body.

The available information suggests that the gabbro magma was injected as a concordant lens wholly within sandstones and graywackes of the Tillman Metasedimentary Group.

CHARACTER IN SUBSURFACE

A suite of closely allied gabbroic and dioritic rocks comprises the Raggedy Mountain Group in the subsurface region of southwestern Oklahoma. Diallage gabbro and anorthosite predominate. In most of the deeper well penetrations, and in those areas of deepest erosion, they are accompanied by olivine-bearing rocks. Olivine gabbro, troctolite, and one occurrence of altered pyroxene-olivine-magnetite rock have been recorded. Quartz diorite, diorite, and gabbro-diorite are more common in subsurface than on the outcrop, and are especially characteristic of the upper part of the gabbro body in the western area, near the Oklahoma-Texas border.

Eleven wells penetrated 200 to 1,000 feet of Raggedy Mountain rocks, and one exceptionally deep well penetrated 8,066 feet. Where samples of good quality were available from these wells, it was determined by thin-section examination that the rocks are rhythmically layered as in Wichita Mountains outcrops. All are interpreted as layered differentiates of gabbroic magma injected into metasediments in the form of a huge lens. Locally the rocks have been cataclastically sheared, probably during the Wichita orogeny, whereas at an earlier date they were partly altered to chlorite, carbonate minerals, and zeolites.

Gabbroic rocks.—Diallage gabbro is the most abundant gabbroic rock (pl. XIII-1, 4, 6). It has been recorded from all but 8 of the 27 wells, and it occurs in all parts of the principal gabbro belt as well as in the smaller southern area. Generally it is interlayered with anorthosite, the change resulting from loss of pyroxene. The dominance of pyroxene gabbro is shown by examination of cuttings from the 8,066-foot penetration in the Champlin 1 Hieber well (fig. 14). Forty thin sections were cut from samples at random depths in this well. Thirty-seven are of gabbroic rock, of which 68 percent (25 sections) is pyroxene gabbro. Judging from the sparse control available, it would appear that this kind of gabbro occurs in layers 300 feet to as much as 1,500 feet thick. Anorthosite constitutes about 13 percent of the sequence. It evidently occurs in layers that are much thinner, as they cannot be shown to have a thickness greater than about 100 feet. Similar thicknesses are known in the Stauffer 1 Mayo well (fig. 15).

Olivine-pyroxene gabbro and troctolite also are found in the Hieber well (pl. XIII-2). Together they comprise 16 percent of the

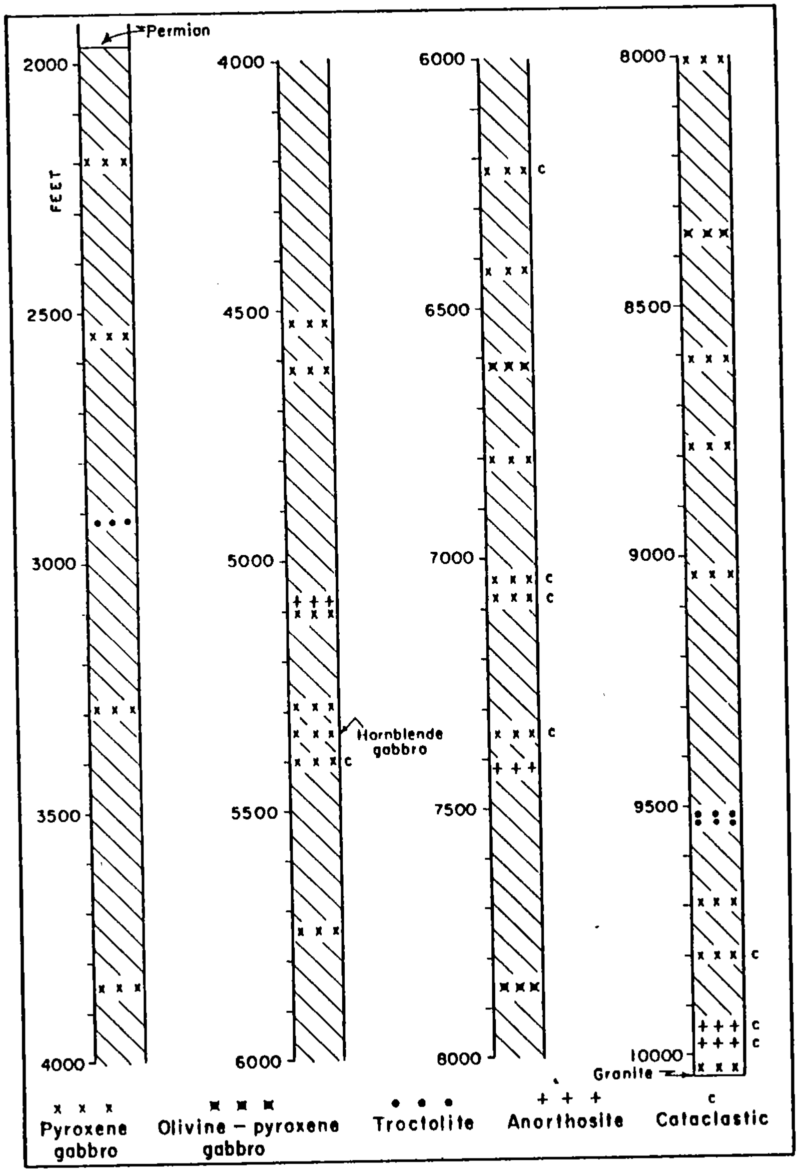

Figure 14. Generalized log of the Raggedy Mountain Gabbro Group (diagonal ruling) in the Champlin 1 Hieber, SW¼ SW¼ NW¼ sec. 30, T. 8 N., R. 20 W., Washita County, Oklahoma. The drilled thickness of 8,066 feet probably is a world's record penetration of gabbroic rocks. Thin sections have been examined where rock symbols are shown.

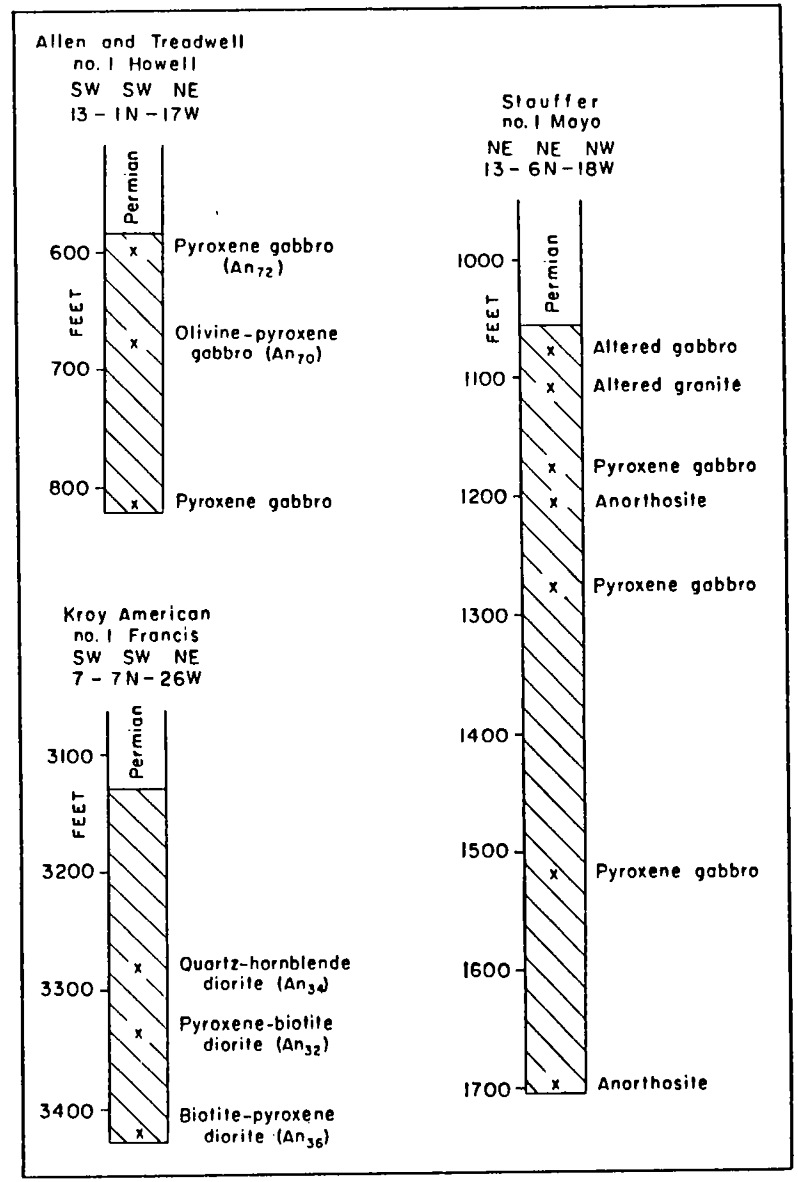

Figure 15. Logs of diorite and gabbroic rocks of the Raggedy Mountain Gabbro Group (diagonal ruling) in three Oklahoma wells. Position of thin section shown by x; An determinations by universal stage. In the Stauffer well much calcite and chlorite are present.

total gabbroic sequence and occur in layers perhaps 100 to 300 feet thick. With one exception, olivine-bearing rocks are conspicuously lacking from the upper 4,600 feet of the gabbro body, at a depth range of 2,000 to 6,600 feet. Below this depth, in the lower 3,400 feet of penetration, they constitute about 25 percent of the gabbroic rock. That there is a downward increase in percentage of olivine probably is a valid generalization. The estimated percentage of olivine is hardly more than a rough guess, however, owing to inadequacy of the sampling method and to the probability that faulting has disrupted the layered sequence. Shearing and cataclastic breakage characterize many thin-sectioned samples from this well.

Olivine-bearing rocks are found in four other wells, three from Kiowa County (Kw-17, Kw-46, Kw-70) and one from Tillman County (Ti-38). Three of them contain normal olivine-pyroxene gabbro, and one (Kw-17) contains an altered pyroxene-olivine-magnetite rock. Troctolite has been found only in the Hieber well, although it is doubtless widely distributed within the Wichita Province.

Cores taken at the bottom of the Hieber well are medium-grained micrographic leucogranite, containing 30 percent quartz, 41 percent perthite, and 24 percent oligoclase. It is Wichita granite of the type that occurs in the Cold Springs area, and is of interest in showing the great depth at which micrographic granite intrudes Raggedy Mountain gabbro.

Modes of the common gabbroic rocks from subsurface are given in table 12. Pyroxene gabbro is the most common type, and in relatively unaltered specimens it has the following generalized mineral percentages: 55 plagioclase, 25 pyroxene, 3 hornblende, 5 biotite, 8 iron ore, and 4 percent accessory minerals and alteration products. Plagioclase grades from labradorite to bytownite, with a normal range of An_{65} to An_{75}. By the addition of olivine these rocks grade into olivine gabbro, in which olivine is present in amounts as great as 17 percent, generally occurring at the expense of pyroxene and iron ore. Troctolites contain much olivine and little or no pyroxene. The sample selected as typical from the Hieber well is essentially an olivine-plagioclase rock, with 10 percent iron ore and 2 percent biotite. In anorthosites the plagioclase content is at least 90 percent, and in the two examples chosen for table 12 it ranges from 90 to 100 percent. Plagioclase of the olivine-bearing rocks and of the

anorthosites is typically bytownite, of which the An content is 70 to 75 percent.

The subsurface gabbroic rocks are coarse grained, the crystal size generally being greater than 3 mm and locally greater than 1 cm (pl. XIII-1). Some of the rocks probably have even coarser texture, but their maximum grain size could not be determined

TABLE 12.—MODAL ANALYSES OF SUBSURFACE ROCKS FROM THE RAGGEDY MOUNTAIN GABBRO GROUP

(Values given are percent by volume. All An determinations by universal stage. Accessory and alteration minerals are omitted.)

Rock type	*Well number and thin-section number*	*Plagioclase*	*Pyroxene*	*Hornblende*	*Biotite*	*Olivine*	*Quartz*	*Iron ore*
Quartz diorite	Bk-6-2 (1053)	61 (An_{33})	-	13	7	-	9	3
	Bk-44-1 (1133)	56 (An_{34})	7	13	8	-	6	5
	Ti-37-1 (1117)	55 (An_{45})	1	16	1	-	6	11
	Bk-57-6 (1793)	58 (An_{44})	6	16	8	-	7	4
Diorite	Bk-10-1 (1056)	56 (An_{40})	5	16	11	-	3	4
	Bk-57-10 (1797)	50 (An_{44})	12	18	11	-	1.9	5
Gabbro diorite	Gr-50-1 (1042)	51 (An_{52})	2	19	9	-	-	7
Pyroxene gabbro	Kw-99-1 (1423)	54 (An_{65})	29	2	2	-	-	12
	Bk-43-4 (1468)	52 (An_{73})	24	5	14	-	1	4
	Ti-38-1 (1428)	59 (An_{72})	17	1	2	-	-	8
Olivine-pyroxene gabbro	Wt-3-10 (1440)	47 (An_{74})	17	9	-	17	-	6
	Ti-38-2 (1429)	58 (An_{70})	26	2	2	8	-	3
Troctolite	Wt-3-13 (1443)	65 (An_{74})	-	-	2	22	-	10
Anorthosite	Kw-3-1 (1414)	95 (An_{75})	3	-	-	-	-	1
	Wt-3-9 (1439)	100 (An_{79})	-	-	-	-	-	-

because individual crystals are larger than the cutting chips. At a few localities the gabbro is fine grained. The texture of pyroxene gabbro and olivine-pyroxene gabbro in the upper 100 feet of well Ti-38 is decidedly finer than normal, as the plagioclase laths are 0.5 to 1.0 mm long.

Characteristic textural fabrics are hypidiomorphic, xenomorphic, and ophitic (pl. XIII). Pyroxene gabbro normally is hypidiomorphic granular or ophitic. Large crystals of pyroxene ophitically enclosing subhedral laths of plagioclase are commonly encountered in cuttings. None of the subsurface samples can be shown to contain single pyroxene crystals one foot or more long, such as are known from exposures in the Wichita Mountains.

With increasing plagioclase content, the femic minerals tend to become restricted to an intergranular position, and the resulting fabric is hypidiomorphic granular. Most of the anorthosites are xenomorphic equigranular and are somewhat finer grained than normal gabbros. Some show pronounced length orientation of the plagioclase, are somewhat coarser, and are typically allotriomorphic.

Plagioclase of the gabbroic rocks is well twinned and subhedral to nearly euhedral, and not uncommonly contains minute acicular inclusions of rutile and perhaps hypersthene. Common alteration products of the plagioclase are sericite and prehnite, together with clay minerals and zeolites of uncertain composition. Replacement patches and veinlets of calcite are locally abundant.

Clinopyroxene, generally diallage, is the dominant femic mineral. Much of it is characterized by schiller inclusions, pale grayish-brown color, and barely perceptible pleochroism. In the large crystals of some gabbros, diallage surrounds a core of orthopyroxene. Alteration products are chlorite, fibrous green biotite, or a tremolitic amphibole with associated calcite. Many large pyroxene crystals are mottled by included hornblende.

Olivine is found as anhedral granules, either as scattered individuals or in clustered groups. In the gabbros it is partly embedded in pyroxene or is surrounded by a thin pyroxene rim, whereas in the troctolites it occurs as grains interspersed with plagioclase. Iddingsite is a common product of deuteric alteration, although much olivine of the subsurface rocks is surprisingly fresh. Chlorite and fibrous green biotite, and locally hydrous iron oxides, also occur. Cracks in the olivine are commonly filled with iron ore and serpentinelike chloritic minerals.

Biotite of the gabbroic rocks is a reddish-brown titaniferous variety, occurring as a rim around an earlier magmatic mineral or as well-crystallized grains between plagioclase laths.

Dark-brown basaltic hornblende and, less commonly, green hornblende occur as later anhedral crystals or as a thin rim around iron ore or pyroxene.

Apatite is a persistent accessory mineral in the gabbros but is rare or absent in the plagioclase-rich anorthosites. Normally occurring as colorless euhedral prisms, the apatite crystals range in length from 0.1 to 0.5 mm.

Grains of iron ore are universally present, even in the anorthosites, but they are best developed in the gabbros and generally constitute 5 to 12 percent of these rocks. Many of the grains are ilmagnetite, consisting of alternate lamellae of ilmenite and magnetite. Iron ore also occurs as symplektic intergrowths with pyroxene or its alteration products.

Epidote and prehnite are late deuteric minerals in the gabbroic rocks, occurring as intergranular crystals and as irregular replacement masses in plagioclase.

Finally, some of the rocks have undergone mechanical deformation of varying intensity (pl. XIII-3). Along major faults they are brecciated and mylonitic, in extreme cases having been reduced to a mineral paste of submicroscopic material that retains relict eyes of plagioclase. Locally the plagioclase laths are bent, distorted, or completely sheared. Because there is little or no attendant mineralization, the cataclastic features are believed to have originated long after consolidation of the rocks, and probably were formed during faulting accompanying the Wichita orogeny in Pennsylvanian time.

Diorites.—Rocks of the Raggedy Mountain Gabbro Group are mostly gabbroic in composition, as they are characterized by plagioclase in the labradorite-bytownite range and generally contain pyroxene and/or olivine. In addition, hornblende-rich diorites and quartz diorites typify a large subsurface area and are clearly part of the group. Another kind of hornblende-rich rock, the plagioclase of which is sodic labradorite, also is known in subsurface. It is classed as gabbro-diorite and is regarded as transitional between the normal gabbros and the quartz diorites. The two wells of gabbro-diorite are in central Greer County (Gr-50, Gr-55). A modal analysis of rock from one of these wells is given in table 12.

As mapped in subsurface, all the dioritic rocks lie close to the overlying granite and are doubtless at or near the top of the gabbro body. At least 875 feet of diorite is present locally, as indicated by maximum penetration in wells. The feldspar of the diorites is andesine (An_{33-45}). Potassium feldspar has not been observed in any of the samples examined, and thus the rocks can neither be termed granodiorites nor can they be considered to have originated through contamination by granitic magma. They are diorites representing the last stage in the straightforward differentiation of the gabbro magma.

Probable equivalents of the diorites are the microdiorite dikes in the Cold Springs area of the Wichita Mountains and the subsurface flows of andesite that are present in the Navajoe Mountain Basalt-Spilite Group. Similarly, the basaltic flows of the Navajoe Mountain Group are considered to be the extrusive equivalents of the gabbros.

The principal area of diorite known in southern Oklahoma is in southwestern Beckham County. In this area six wells have been drilled into the Raggedy Mountain Group, of which five (Bk-6, Bk-10, Bk-42, Bk-44, and Bk-57) penetrated only diorite and quartz diorite. The quartz diorites contain approximately 60 percent andesine, 15 percent hornblende, 7 percent biotite, 5 percent pyroxene, and 6 to 9 percent quartz (table 12). The two deepest penetrations of Raggedy Mountain diorite are 299 feet and 875 feet, respectively, in the Kroy American 1 Francis and the Barnes 1 Gamble wells. In each of them quartz diorite in the upper part of the well grades downward into normal diorite, poor in quartz and rich in biotite, hornblende, and pyroxene. The plagioclase of these diorites is andesine in the range of An_{40-47}.

The hornblende of the diorites is green to blue green, in contrast to the dark-brown basaltic hornblende of the gabbros, and the biotite is reddish brown. Sphene is typically present in the diorites, whereas it is generally lacking in the gabbros. The diorites are typically medium grained and therefore finer textured than normal gabbro of the Raggedy Mountain Group.

Distribution of the wells indicates that the diorite area in Oklahoma has a minimum length of 10 miles. Wells across the state line, in Collingsworth and Wheeler Counties, Texas, contain quartz diorite of entirely similar composition (Flawn, 1956, pl. I), and they extend the diorite through an area at least 30 miles long. Total length of the Raggedy Mountain Group in Oklahoma and Texas is 110 miles (pl. V). The eastern area is almost wholly gabbro, but diorite occurs above it in the westernmost area and is present in more than 25 percent of the known length of the gabbro body. Time equivalence of the gabbro and diorite is demonstrated, moreover, by the isotopic-age data of table 4.

Tillman Metasedimentary Group

INTRODUCTION

A sedimentary sequence of probable Early Cambrian age, dominated by graywacke but also containing siltstone, shale, sandstone, arkose, and bedded chert, is the oldest rock group of the Wichita Province. Through widespread intrusion by Wichita granites the sedimentary strata have been converted regionally into biotite-containing metasediments and, locally, nearest the intrusive contacts, into mica schists and hornfels. This sequence of closely related rocks is believed to be several thousand feet thick and to represent the first stage in the filling of the Southern Oklahoma geosyncline. It is here called the Tillman Metasedimentary Group, the name being taken from Tillman County where the rocks have been penetrated in subsurface by numerous wells.

Rocks of the Tillman Group are known to occur over approximately 1,350 square miles in a subsurface area south of the Wichita Mountains outcrops (pl. I). Eight wells in Tillman County, three in Jackson County, and two in Cotton County furnish the information now available. Another and much larger region where Tillman metasediments probably are present but, owing to their great depth, have not yet been drilled, is outlined by the broad northwestward-trending belt of Carlton rhyolite between the Wichita Mountains and the eastern part of the Arbuckle Mountains.

Also included in the Tillman Metasedimentary Group is the Meers Quartzite. It has not been encountered by drilling but is known as inclusions in Raggedy Mountain gabbro and in Wichita granite at several outcrop localities in the Wichita Mountains.

PETROGRAPHY

Knowledge of the petrographic character of the Tillman metasediments is derived mainly from a study of cuttings from 13 wells in Jackson, Tillman, and Cotton Counties (table 13). The deepest penetrations of 325 and 320 feet are recorded in two wells. Three additional wells each penetrated more than 200 feet, and each of the remaining wells penetrated less than 100 feet. Thirty-five thin sections made from these samples show that the dominant rock is dark meta-graywacke and argillite, both characterized by the development of crystalloblastic biotite. Of lesser abundance are schistose rocks and hornfels that have been derived from graywacke and shale at or near intrusive contacts with granite. A third rock type in subsurface is bedded chert, partly recrystallized by regional metamorphism yet still retaining its laminated bedding and the questionable tests of radiolarians. Finally, the strongly metamorphosed Meers Quartzite occurs as inclusions in outcropping gabbro and granite of the Wichita Mountains (table 13).

As here reconstructed, the original rocks of the Tillman Group were sedimentary and almost wholly clastic. They consisted chiefly of poorly sorted matrix-filled graywacke interbedded with shale, together with some more cleanly washed and better sorted sandstone and, locally, with bedded chert. Carbonate rocks and volcanics have not been found, although they may occur in the lower and more deeply buried parts of the group.

Meta-graywacke and Argillite

Poorly sorted and sandy-textured dark-colored sediments, characterized by about 25 percent paste matrix surrounding the sand grains, constitute the common graywackes of southern Oklahoma (pl. XIV). The angular to subangular clastic grains are polygenetic, consisting mostly of various feldspars, quartz, chert, quartzite, and phyllite or mica schist, whereas the embedding medium or matrix is finely divided silt and clay. With respect to diversity of composition of the sand-sized grains, their angularity and poor sorting, and the widespread presence of an embedding matrix, these rocks are strictly like the normal graywackes of the world as described by Pettijohn (1949, p. 243-255). In the Oklahoma graywackes the fine-grained matrix has been almost entirely reconstituted and now contains crystalloblastic biotite, muscovite, or chlorite. The term

meta-graywacke thus is more appropriate and is used in this report.

Texture of the meta-graywackes ranges widely, and sorting is poor regardless of the modal grain size. The coarsest rocks are medium textured. The modal diameter of their constituent grains is about 0.3 mm, but the range in a single specimen is typically from 0.05 to 0.7 mm and, in some, up to 1.5 mm. In fine-grained and very fine-grained graywackes the maximum grain diameter is 0.7 and the mode is 0.25 to 0.15 mm. A silty clay matrix constitutes 15 to 30 percent of these rocks. Excellent examples were recovered from wells Jk-9, Jk-22, Ti-12, Ti-13, Ti-20, and Ct-3 (table 13).

Also common in the Tillman Group are graywacke metasiltstones. They differ from the coarser rocks chiefly in their finer average grain size, which generally is in the range of 0.04 to 0.05 mm. The paste matrix increases in the finer textured graywackes to as much as 75 percent, and from this textural composition the graywacke siltstones grade insensibly into silty shales. This type of rock is well shown in the Wadley 1 Capps (well Ti-4, table 13).

The most abundant detrital grains of the meta-graywacke suite are quartz, various feldspars, chert, and quartzite, locally with a small percentage of phyllite. Detrital heavy minerals are exceptionally rare. Quartz and two or more feldspars dominate most rocks, although the relative percentage of quartz to feldspar is highly variable. Oligoclase and other intermediate plagioclases occur with perthite and orthoclase and, rarely, with microcline, and evidently have been derived by rapid weathering of granodioritic rocks. The quartz has been derived partly from the disintegration of these rocks and partly from quartzitic sediments. Quartzite fragments, composed of grains having undulose extinction and highly sutured boundaries, occur abundantly as sand-sized grains in some graywackes but are absent in others (pl. XIV-6). Subangular grains of chert are universally present, commonly making up 5 percent of the total rock. Weakly schistose sericite-rich phyllite derived from low-rank metamorphic rocks can be identified as elongate rounded fragments in most of the coarser textured meta-graywackes (pl. XIV-5).

The coarser grains in the meta-graywacke are separated from each other and suspended in a matrix that was originally a silty clay paste (pl. XIV-1). In most specimens this matrix is now a reconstituted finely crystalloblastic aggregate of biorite, quartz, and feld-

TABLE 13.—SUMMARY OF WELLS AND ROCK TYPES IN TILLMAN METASEDIMENTARY GROUP

	Company and farm	County and well number	Penetration depth and thickness	Rock types
Meta-graywacke and Argillite	Burke No. 1 Estes	Jackson (Jk-9)	830-1,150 T.D. (320 feet)	Very fine-grained meta-graywacke, consisting of 0.05-0.1 mm detrital grains in 50-75% reconstituted biotite-containing matrix. Interstratified with hornfelsic biotite argillite and silicified chlorite argillite. Cut by granite stringers. Thin sections Jk-9-1, -2, -3, -4.
	Gutowski No. 1 Booker	Jackson (Jk-22)	820-1,031 T.D. (211 feet)	Fine- and medium-grained meta-graywacke. Diameter of average grain is 0.25 mm: grains are embedded in 10-30% biotitic and/or chloritic matrix. Interstratified with thin beds of biotitic argillite. Rocks are cut by veins of coarsely granular chert. Thin sections Jk-22-1, -2, -3, -4, -5.
	Wadley No. 1 Capps	Tillman (Ti-4)	760-1,085 T.D. (325 feet)	Interstratified argillite, silty argillite, metasiltstone, and very fine-grained meta-graywacke. Cut by veins of coarsely granular chert. Thin sections Ti-4-1, -2.
	Russell No. 1 Goodwin	Tillman (Ti-12)	1,085-1,133 T.D. (48 feet)	Medium-grained meta-graywacke. Grains average 0.35 mm, set in 15% matrix consisting of crystalloblastic biotite, quartz, feldspar, and hornblende. Thin section Ti-12-1.
	Honolulu No. 1 Burba	Tillman (Ti-13)	2,475-2,783 T.D. (308 feet)	Fine- and medium-grained meta-graywacke. Matrix 15-20%, contains crystalloblastic biotite and small amounts of hornblende, muscovite, and epidote. Thin interbedded layers of hornfelsic argillite. Thin sections Ti-13-1, -2, -3, -4, -5.
	Continental No. 1 Smith	Tillman (Ti-20)	3,220-3,373 T.D. (153 feet)	Medium-grained meta-graywacke. Modal grain size is 0.25 mm; largest grain is fragment of quartzite 1.5 mm long. Matrix is about 20%, contains crystalloblastic biotite and epidote. Thin section Ti-20-1.
	Ellison No. 1 Harris	Cotton (Ct-3)	2,260-2,296 T.D. (36 feet)	Medium-grained meta-graywacke. Detrital grains average 0.3 mm, range from 0.05 to 0.5 mm. About 25% matrix, containing abundant crystalloblastic biotite. Thin sections Ct-3-1, -2.
	Mid Continent No. 1 Perry	Tillman (Ti-18)	1,491-1,748 T.D. (257 feet)	Medium-grained meta-graywacke, the matrix of which contains crystalloblastic hornblende, biotite, muscovite, and epidote. Grades downward into hornfelsic graywacke and at bottom into quartz-plagioclase-biotite-hornblende hornfels. Thin sections Ti-18-1, -2, -3, -4.
	Sun No. 1 Parks	Tillman (Ti-21)	1,915-1,972 T.D. (57 feet)	Mica schist and biotite-amphibole schist. Rock is cut by biotite granodiorite. Thin sections Ti-21-1, -2.
Schistose rocks — Hornfels	Ray No. 1 Madison	Tillman (Ti-22)	1,870-1,894 T.D. (24 feet)	Weakly schistose arkosic hornfels, consisting of equigranular quartz, feldspar, and biotite. Cuttings contain fragments of microcline-bearing granodiorite. Thin section Ti-22-1.
	Mid Continent No. 1 Overton	Tillman (Ti-35)	1,668-1,721 T.D. (53 feet)	Biotite schist, muscovite schist, and epidote-muscovite hornfels. Thin sections Ti-35-1, -2, -3.
	Johnson & Russell No. 1 Holmes	Cotton (Ct-2)	2,244-2,295 T.D. (51 feet)	Schistose fine-grained meta-graywacke and biotitic silty argillite. Detrital grains in graywacke are embedded in 35% matrix, which contains much crudely aligned crystalloblastic biotite. Thin sections Ct-2-1, -2.
Bedded chert	Schaffer No. 1 Howard	Jackson (Jk-25)	890-959 T.D. (69 feet)	Brownish-red and dark-green laminated chert containing sparsely developed muscovite, biotite, and chlorite. Rocks are cut by a few veins of coarsely granular quartz. Radiolarians (?) numerous in some cuttings. Thin sections Jk-25-1, -2, -3.
Meers Quartzite	Occurs as inclusions in Raggedy Mountain gabbro and Wichita granite at several outcrop localities in Comanche County. Inclusions are as much as 1,000 feet long. Rock types include nearly pure quartzite, micaceous quartzite, sillimanite quartzite, and feldspathized quartzite, all derived from quartzose and argillaceous sandstones. Quartz normally is recrystallized to plane-bordered mosaic of equant grains. Feldspathized quartzite is locally banded and resembles gneiss.			

TABLE 14.—MODAL ANALYSES OF META-GRAYWACKE FROM THE TILLMAN GROUP

Company and Farm	Well and thin-section number	Rock type	Percent sand-sized detrital grains						Matrix	
			Quartz	Feld-spars	Quartz-ite	Chert	Phyl-lite	Total grains	Per-cent	Description
Ellison No. 1 Harris	Ct-3-1 (1733)	Medium-grained meta-graywacke	30	35	-	10	3	78	22	Finely crystalloblastic biotite, quartz, feldspar, and epidote
Continental No. 1 Smith	Ti-20-1 (1425)	Medium-grained meta-graywacke	35	20	13	5	2	75	25	Finely crystalloblastic biotite, quartz, feldspar, epidote, and muscovite
Gutowski No. 1 Booker	Jk-22-3 (956)	Very fine-grained meta-graywacke	25	40	-	5	-	70	30	Finely crystalloblastic chlorite, biotite, quartz, feldspar, and epidote, partly silicified
Burke No. 1 Estes	Jk-9-3 (911)	Very fine-grained meta-graywacke	12	25	-	3	-	40	60	Well-crystallized biotite, quartz, and feldspar

spar, with lesser and variable amounts of epidote, chlorite, muscovite, and hornblende. Finely crystalline silica has been introduced irregularly, both as veinlets and as replacement chert. Biotite, the most typical mineral, ranges in degree of idioblastic growth from tiny sprouted shreds to well-formed books, all less than 30 microns in diameter.

Metamorphic reorganization of the graywackes over most of southern Oklahoma is limited to the fine-grained matrix. It is reconstituted to the point where little or no original material remains, except silt-sized detrital quartz grains, yet the sand-sized grains of feldspar, quartz, and even phyllite are virtually unaffected. These larger grains retain their angular to subrounded shapes, changing only by a slight fraying of their borders and by the introduction of sparse sericite and epidote into the larger fragments of feldspar.

The matrix material increases in percentage with progressive loss of silt and sand, and the rocks grade into beds of shale that are interstratified with the graywacke. The shales are much less common than the graywacke. Like the matrix of the graywackes, the materials of the shales have been reorganized to finely crystalloblastic micas, quartz, feldspar, finely granular epidote and hornblende, and traces of carbonate minerals and sphene. Such rocks are the argillites of the Tillman Group. They show no preferred orientation of platy minerals and are not slates. Other descriptive names for this rock are biotitic argillite, hornfelsic argillite, and meta-argillite, each of these terms conveying the meaning that the argillaceous rocks are reconstituted on a regional scale.

Modal analyses of four common meta-graywackes of the Tillman Group are given in table 14 and a fifth is given, along with a chemical analysis, in table 18. The chemical analysis is that of a typical medium-grained meta-graywacke (Russell 1 Goodwin, well Ti-12). Its matrix is fully crystalloblastic, and the unrecrystallized sand-sized grains consist of feldspars, quartz, quartzite, and chert. Essential features of the analysis are approximately 67 percent SiO_2, 16 percent Al_2O_3, 4 percent FeO, and 2 to 3 percent each of MgO, CaO, Na_2O, and K_2O. As this analysis does not differ significantly from the world-wide averages of graywacke cited by Pettijohn (1949, table 64, p. 250), it is clear that the Oklahoma rock is chemically normal for the graywacke family. Also established is the conclusion that the original chemical character of the sediment has not been appreciably changed by crystalloblastic reorganization of the matrix. Indeed, the principal change probably has consisted of the formation of biotite, chlorite, and muscovite from a detrital clay rich in chlorite and sericite.

Schistose Rocks and Hornfels

The common graywackes and shales of the Tillman Group grade into mica schists and hornfels. Detrital grains in some of the schistose rocks are preserved, the schistosity being shown by parallel alignment of micas that have grown by recrystallization of the matrix (pl. XIV-4). The more strongly reconstituted rocks contain well-aligned biotite and/or muscovite grains that have sprouted between, within, and across the detrital grains. The grains themselves show by their plane-surfaced common boundaries that they have been recrystallized. Schistose rocks are found in wells Ti-21, Ti-22, Ti-35, and Ct-2.

Sediments that are completely recrystallized into hornfels occur with meta-graywackes and schists. The fabric of detrital grains is destroyed, and the new rock consists generally of crystalloblastic quartz, plagioclase, biotite and/or muscovite, and hornblende. In the Mid-Continent 1 Perry (well Ti-18), 257 feet of Tillman metasediments was penetrated. The upper meta-graywackes grade progressively through hornfelsic graywacke, with partial destruction of detrital grains, into a wholly reconstituted quartz-plagioclase-biotite-actinolitic hornblende hornfels (pl. XIV-2).

The downward increase in degree of recrystallization, plus the association of schists with hornfels, is strong evidence that intrusive igneous rocks are concealed at shallow depth. Wells drilled to the same general depth in the same general area penetrate either normal meta-graywacke, schist, or hornfels, thus demonstrating that the top of the intrusive body, or bodies, is not everywhere at the same level. As here interpreted, the bodies probably are irregular plutons and sills of Wichita granite. Although the wells drilled into the Tillman Group have not penetrated large granite bodies, some of them have yielded granite cutting chips which probably represent apophyses. The widespread intrusion of Wichita granite into Tillman strata is believed to have been the principal source of heat that regionally recrystallized the matrix of the graywackes, converted the shales into argillites, and, where near an intrusive contact, changed these rocks into schists and hornfelses.

Bedded Chert

Bedded cherts are interstratified with thick graywacke sequences of many different geologic ages. Notable are the siliceous iron formations in the Precambrian of the Canadian Shield, cherts and siliceous shales in the Stanley and Jackfork (Mississippian) of Oklahoma, and the radiolarian cherts in the Franciscan (Jurassic) of California. Discovery of laminated chert in the Schaffer 1 Howard (well Jk-25) demonstrates that siliceous rocks also are present in the Tillman Metasedimentary Group, of probable Early Cambrian age, in the Wichita Province of southwestern Oklahoma.

Sixty-nine feet of chert was drilled in the Howard well. Much of the chert is laminated (fig. 16). The cuttings are essentially alike throughout, consisting of reddish-brown and dark greenish-gray very finely crystalline chert, with occasional veinlets of coarsely granular quartz. As much as 5 percent of some cuttings is composed of finely crystallized biotite and muscovite, or muscovite and chlorite, which shows that clay minerals were originally present in small amount. The reddish chert contains numerous feathery and irregular dark-red micrograins of an iron oxide mineral (hematite or turgite?).

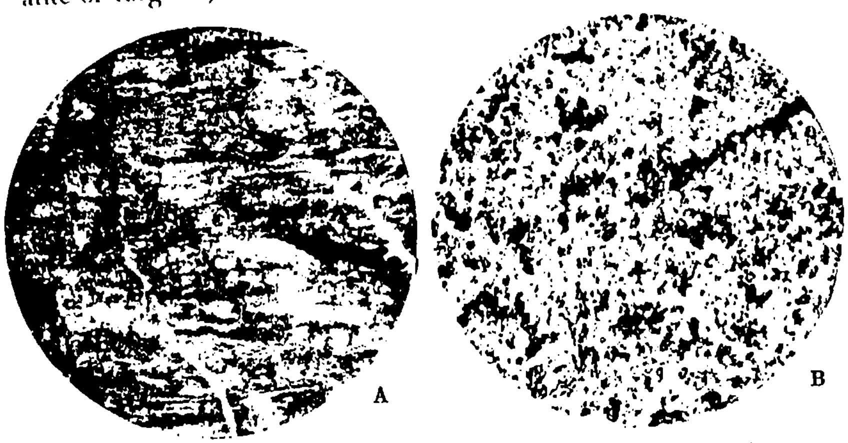

Figure 16. Photomicrographs of bedded chert from the Tillman Metasedimentary Group.

A. Laminated chert, Schaffer 1 Howard, SE¼ SE¼ SW¼ sec. 9, T. 2 N., R. 19 W., depth 940-950 feet. Darker argillaceous laminae emphasize the bedding. Note cross-cutting quartz veins. Thin section Jk-25-3. Ordinary light. Field diameter: 1.5 mm.

B. Chert, same as A. Shreds of crystalloblastic biotite and chlorite, together with ragged iron ores, are set in a fine-grained quartz mosaic. Ordinary light. Field diameter: 0.11 mm.

The probability that the rocks are bedded cherts, and not thoroughly silicified shales or argillites, is strengthened by the occurrence in these rocks of undistorted spherical bodies that appear to be radiolarians. Mostly about 10 microns in diameter, the bodies occur in random distribution or are richly concentrated along thin layers of the chert. No ornamentation except spines, some oppositely paired, can be seen in thin section, yet the forms are nevertheless much like some of the radiolarians illustrated from New York Ordovician cherts by Ruedemann and Wilson (1936). The spherical ornamented bodies are not composed of silica but consist of a pale-green mineral that evidently has replaced the radiolarian tests. L. R. Wilson, research professor of geology at The University of Oklahoma, has kindly examined the thin sections from the Howard well. He has identified the spherical bodies as being questionable radiolarians, occurring in association with questionable hystrichosphaerids, green algae, and bacteria.

The occurrence of radiolarians and hystrichosphaerids would support the conclusion derived from other evidence that the cherts are of sedimentary origin and were deposited in a marine environment.

Placement of the bedded cherts in the Tillman Group is based upon their geographic occurrence within the Tillman subcrop area and upon the expected association of such cherts in a sequence of graywackes. Meta-graywacke was not penetrated in the Howard well but does occur in well Jk-9, three miles north-northeast of the Howard well, and in the two nearest control wells immediately to the southeast (pl. I).

Meers Quartzite

The final type of metasedimentary rock assigned to the Tillman Group is known only as inclusions in Raggedy Mountain gabbro and Wichita granite from outcrops in the Wichita Mountains region. Called the Meers Quartzite, from its occurrence as large xenoliths in gabbro just south of Meers post office (Hoffman, 1930, p. 31), the quartzite has now been found as numerous inclusions in granite in the area of Tarbone Mountain, four miles southwest of Meers, and as scattered inclusions in granite near Medicine Park, four miles southeast of Meers. Even though the sand grains have been recrystallized at most localities, the character of the rock

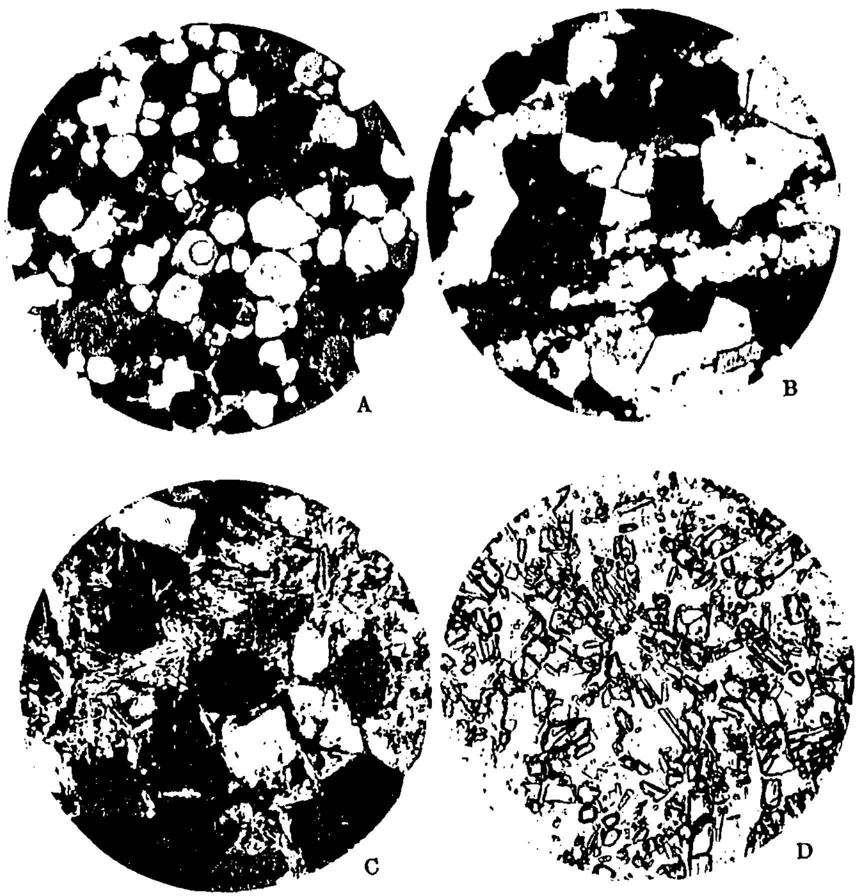

Figure 17. Photomicrographs of Meers Quartzite.

A. Inclusion in Raggedy Mountain gabbro, SE¼ sec. 32, T. 4 N., R. 13 W. Well-rounded relict quartz sand grains are surrounded by optically continuous perthite that contains (center) a little micrographic intergrowth. Polarized light. Field diameter: 2.8 mm.

B. Contorted banded inclusion in Wichita granite, SE¼ NE¼ NE¼ sec. 19, T. 3 N., R. 12 W. Parallel bands of perthite have been injected into the quartzite. Many of the quartz grains are in an advanced stage of reconstitution, the original grain outline having been destroyed by new growth that resulted in the formation of planar contacts. Polarized light. Field diameter: 2.8 mm.

C. Inclusion in Raggedy Mountain gabbro, SE¼ sec. 32, T. 4 N., R. 13 W. Small unoriented sericite flakes occupy an intergranular position between partly reconstituted quartz sand grains. Polarized light. Field diameter: 0.7 mm.

D. Inclusion in Raggedy Mountain gabbro, SE¼ sec. 32, T. 4 N., R. 13 W. Abundant sillimanite needles (high relief) are randomly oriented and have grown through the surrounding quartz grains. Ordinary light. Field diameter: 0.7 mm.

TABLE 15.—MODAL ANALYSES OF MEERS QUARTZITE

Rock type	*Locality*	*Enclosing rock*	*Quartz*	*Silliman-ite*	*Mus-covite*	*Biotite*	*Feldspars*	*Others*	*Remarks*
Micaceous quartzite	SE¼ SE¼ 32-4N-13W Meers area	gabbro	82	-	7	6	1	Chlorite, 3 Zircon, 1 Rutile Magnetite	Clay matrix recrystallized to micas; quartz grains subrounded
Quartzite	NE¼ SE¼ 32-4N-13W Meers area	gabbro	99	-	tr.	-	-	Epidote Magnetite	Quartz mosaic
	SE¼ NE¼ 34-4N-14W Tarbone Mtn. area	granite	99	-	tr.	-	-	Epidote Chlorite Magnetite	Quartz mosaic
Sillimanite quartzite	SE¼ SE¼ 32-4N-13W Meers area	gabbro	85-95	5-10	tr.	1-3	-	Magnetite Zircon Apatite Rutile	Sillimanite and biotite clustered within quartz mosaic
			(range in three thin sections)						
	SE¼ NW¼ NE¼ 34-4N-14W Tarbone Mtn. area	granite	69	26	4	-	-	Zircon Magnetite Sphene	Sillimanite in clustered prisms and needles, with muscovite alteration
Feldspathized quartzite	SE¼ SE¼ 32-4N-13W Meers area	gabbro	64	-	1	10	Or 10 Mi 5 Pl 10	Rutile	Feldspars interstitial to quartz. Or is perthitic, partly intergrown with quartz.
	NE¼ NE¼ 19-3N-12W Medicine Park area	granite	65-78	-	-	1-2	Perthite, 20-30	Magnetite Apatite Zircon	Feldspar introduced in thin layers giving gneissic appearance
			(range in three thin sections)						

is plainly indicated by typical quartzite fabrics and mineral composition and by a purity in some thin sections of 99 percent quartz. The formation of newly recrystallized minerals, such as sillimanite, and the introduction of such components as perthite and perthitic micropegmatite are the principal additional changes (fig. 17).

Recrystallization of the detrital quartz has resulted in the formation of closely packed grains bounded by plane surfaces, much like a mosaic of polygonal blocks. No strongly sutured boundaries are developed, and the quartz grains do not show undulatory extinction or strain shadows.

Four kinds of quartzite are found in the Meers (table 15). That which is least altered shows subrounded quartz grains set in a matrix of muscovite, biotite, and chlorite, thus resembling the metagraywackes of Tillman County. The other three types are more strongly recrystallized. One is nearly pure recrystallized quartz; another is sillimanite quartzite, the sillimanite content ranging from 5 to 30 percent; and the fourth is feldspathized quartzite, the feldspar having been introduced from the magma of the surrounding gabbro or granite. The feldspar is introduced interstitially or in the form of parallel, partly contorted bands.

Meers area.—Quartzite inclusions in Raggedy Mountain gabbro near Meers have been described by Taylor (1915, p. 32), Hoffman (1930, p. 31), and Merritt (1948). The two principal inclusions in this area are the largest known in the Wichita Mountains. Each is about 1,000 feet long and as much as 500 feet wide. They occur with eight smaller inclusions in an area 1 mile long and 0.5 mile wide, in SE¼ sec. 32 and S½ S½ sec. 33, T. 4 N., R. 13 W., and NW¼ NW¼ sec. 4, T. 3 N., R. 13 W.

The typical quartzite contains recrystallized quartz grains averaging about 0.25 mm in diameter, occurring with 5 to 10 percent sillimanite and 1 to 3 percent biotite, and with traces of zircon, magnetite, apatite, rutile, and muscovite. Sillimanite and biotite are clustered together, generally with magnetite, and are recrystallization products of clay minerals originally present in the sandstone. Conversion of the sandstone to quartzite is attributed to the injection of gabbro magma, and the large inclusions may in fact be roof pendants of the sandstone.

From the sillimanite quartzite the rock grades first into feldspathized quartzite and then into a hybrid mixture of quartzite and gabbro. The percentage of quartz diminishes progressively to 64, 55, and 28 percent. In the first stage feldspar is introduced interstitially, marginally replacing the quartz. It consists of perthite, microcline, and plagioclase, of which the perthite is in part micrographically intergrown with quartz. In a later stage labradorite is introduced between the quartz grains, and in a still later stage the quartz is present as contaminating grains in gabbro (Merritt, 1948).

Other types of quartzite in the Meers area differ significantly from that containing sillimanite. One kind is 99 percent quartz, partly recrystallized and partly retaining subrounded grain shape, as shown by secondary growths. It was essentially pure sandstone. The second type represents only slight metamorphic change from a sandstone containing a clay matrix. It shows definitely subrounded quartz grains averaging 0.3 mm in diameter and composing 82 percent of the rock, set in a matrix that is recrystallized to muscovite (7%), biotite (6%), and chlorite (3%). The remaining constituents are zircon (1%), plagioclase (1%), and traces of magnetite and micropegmatite. Much of the quartz contains needles of rutile. The lower metamorphic rank of this rock is clearly shown by the conversion of the argillaceous matrix into muscovite and biotite, instead of sillimanite.

Tarbone Mountain area.—The occurrence of Meers Quartzite in Wichita granite at a locality 4.5 miles southwest of Meers was discovered by Hoffman (1930, p. 31). He described a single inclusion about 50 feet wide and 200 feet long. Later mapping by G. W. Chase of the Oklahoma Geological Survey (manuscript map) showed that quartzite inclusions in granite are common in a belt about 0.5 mile wide and 2.5 miles long, extending southeastward from Hoffman's locality in SE¼ sec. 34, T. 4 N., R. 14 W., to Tarbone Mountain in NE¼ sec. 1, T. 3 N., R. 14 W. Within this area are sillimanite quartzites and nearly pure quartzites. Those of highest purity consist of about 99 percent quartz, entirely recrystallized into a mosaic of grains 0.5 to 2 mm in diameter. Traces of epidote, chlorite, apatite, zircon, and hematite are present. The sillimanite quartzites contain as much as 30 percent modal sillimanite, occurring mainly as bunches of prismatic crystals 0.5 to 6 mm long. Just as that in the Meers area, the sillimanite is judged to have been derived from aluminous clay of the sandstone, and the metamorphism is the result of intrusion by the enclosing igneous rocks.

The type of quartzite evolved appears to have been determined more by the abundance of clay in the sandstone than by the character of the intruding magma.

Medicine Park area.—A new area of Meers Quartzite inclusions in Wichita granite was found in 1959 through mapping for this report by Ham and Denison. Located in NE¼ NE¼ sec. 19, T. 3 N., R. 12 W., 0.5 mile southeast of Medicine Park, the inclusions are conspicuously banded and angular, about 18 inches in maximum diameter, and occur within a fine-grained pink granite. Thin sections cut from the three largest inclusions show that the rocks are feldspathized quartzite. All the quartz is recrystallized to a mosaic of equant plane-surfaced grains, mostly 0.2 to 0.5 mm but partly 1.0 to 1.2 mm in diameter. The larger grains are nearly idiomorphic. The rock is markedly banded by the introduction of perthite along closely spaced parallel layers 0.1 to 1.5 mm thick. These layers are mostly straight but in part they are contorted into S-shaped folds, giving the rock the appearance of gneiss. Introduced with the feldspar is a small amount of brown biotite and tiny granules of iron ore, together with euhedral grains of apatite. The thicker layers are characterized by a micrographic intergrowth of quartz with feldspar and are, in fact, composed of granophyric microgranite.

All the banding is clearly the result of injection of granitic material into the quartzite, following discontinuity planes (bedding?). Contortion of the bands probably took place at the intrusive contact of sandstone with the invading magma. As the granite in the Medicine Park area is interpreted as a sill, injected under a roof of Carlton rhyolite and upon a floor of Raggedy Mountain gabbro, it is probable that the quartzite is not roof rock but was torn from beds below the gabbro and carried upward into the sill chamber.

The quartz content of the quartzite inclusions ranges from 65 to 78 percent, and is inversely proportional to the amount of introduced perthite. Perthite, strongly clouded with dust so that in thin section it stands sharply in contrast with clear quartz, occurs by itself or with granophyric microgranite, in amounts ranging between 20 and 30 percent. Where perthite is interstitial to the quartz grains, it replaces the margins of these grains and produces an irregular scalloped contact, somewhat resembling a sutured boundary. Shreds of brown biotite, small grains of magnetite, and euhedral prisms of colorless apatite, each make up 1 to 2 percent of the rock.

Placement of Meers Quartzite in Tillman Metasedimentary Group.—The pure quartz sandstones and argillaceous sandstones that have been metamorphically changed to Meers Quartzite are here included with the sequence of graywacke, arkose, shale, and chert. All are placed within the Tillman Metasedimentary Group, for in this way the known sedimentary rocks of the Wichita Province are classified in a single broad category. All are older than granite and gabbro, all have undergone metamorphic reconstitution, and all occur in the same geographic region. Moreover, the geologic association of quartzose sandstone with thick graywackes is well known in other provinces, notably in the Ouachita Mountains of Oklahoma and Arkansas where Jackfork quartzose sandstones occur with Stanley graywackes.

Sediments of the Wichita Province are conceivably differentiated into two subgroups—northern and southern. The southern, in Jackson, Tillman, and Cotton Counties, is dominated by graywackes derived from a rapidly rising landmass of igneous and metamorphic rocks. The northern subgroup, in Comanche County, is characterized by quartzose sandstone derived mainly from a source area of older sandstones. Sand-sized quartzite fragments that occur locally in the southern graywacke are atypical of the Meers Quartzite. The quartz of these fragments is fine-grained, sutured, and conspicuously strained, whereas the typical Meers Quartzite is medium- to coarse-grained and composed of quartz that is neither sutured nor strained. The two quartzites are unrelated.

Metamorphism

The original graywackes and shales have been regionally metamorphosed to essentially the same rank throughout the province. All these rocks may now be classified as belonging to the quartz-albite-epidote-biotite subfacies of the greenschist facies (Fyfe, Turner, and Verhoogen, 1958, p. 223), as they have the characteristic mineral assemblage of quartz, albite, and biotite. Epidote, actinolitic amphibole, and muscovite are locally present. Chlorite also is present in many samples, but it is considered to have been formed from biotite and amphibole by retrograde metamorphism.

It is not accurate to refer to the fully reconstituted rocks as "high rank" and the meta-graywackes as "low rank," because both have exactly the same mineral assemblage. As indicated by the mineral composition, the pressure-temperature conditions under which the biotite schists originated were not significantly different from those under which the meta-graywackes originated. The meta-graywackes, however, reached only partial equilibrium. The clay matrix, more sensitive to environmental change, has been reconstituted to an equilibrium assemblage of quartz, biotite, and feldspar, whereas the coarser detritus, being inherently more stable, has been left as untouched relicts. This suggests that, although the graywackes were subjected to temperature and pressure relations sufficiently intense for the formation of biotite, these conditions were not maintained for a long enough time to establish complete equilibrium (and complete reconstitution). This rapid heating and subsequent cooling is in full accord with the sequence of events expected to result from the nonbatholithic type of emplacement which is common for most of the granites of the Wichita Group. The relatively small volume of granite in a sill near a given point is insufficient to have provided sufficient heat, over an extended period of time, to permit complete reconstitution.

GEOLOGIC SIGNIFICANCE

The sedimentary rocks of the Tillman Group are known in subsurface from scattered wells and as inclusions in outcropping igneous rocks. Despite the imperfection of knowledge regarding geographic distribution and thickness of the sedimentary sequence, the rocks themselves are of such distinctive petrologic types that major conclusions can be drawn by comparison with other areas where similar rocks are better exposed and the geologic relations are better known. Of particular significance are the graywackes of the Tillman Metasedimentary Group.

Graywackes are known from many regions. They are characterized by a marine origin, great thickness, a general restriction to orogenic and geosynclinal belts, and a common association with bedded cherts and spilitic submarine pillow basalts. These geologic relations and associations begin in Archean time and continue into the Tertiary, as shown by the studies of Pettijohn (1943, 1949):

> Most graywackes probably are marine. The reducing conditions implied by their dark color; by the pyrite and associated carbonate; by their association with submarine pillow lavas of the spilitic suite; and by the occasional presence of marine fossils—all these considerations bear out the marine nature of graywackes. . . . Graywacke is the most typical sediment of some orogenic belts, and does not occur in any important manner outside of this environment . . . .(1949, p. 254)

> Thickness of the graywacke sequences in Archean and later time ranges between 9,000 and 35,000 feet. (1943, table II, p. 958)

> Graywacke is a petrographically distinct species of arenite which is known also by its associations. . . .Typical are the ellipsoidal greenstones [which are] certainly established for almost every district [in the Archean of the southern Canadian Shield]. . . .The greenstone-graywacke association is established for many other periods. The pillowed greenstones of the Ordovician (?) of Newfoundland, the same rock types of the lower Paleozoic of Wales, the English Lake District, and the southern highlands of Scotland, the Tertiary of the Alps, the lower Paleozoic of New England, the Jurassic of the Coast Ranges of California, the Triassic of Alaska, the early (?) Paleozoic of Australia, as well as the Middle and Upper Huronian of the Upper Peninsula of Michigan, are all associated with the graywacke suite of sediments. All these occurrences are along strongly deformed orogenic belts. (1943, p. 954-955)

> Associated with the Archean graywackes and contemporaneous greenstones are thin, lean, nonproductive iron-bearing formations. . . .Such lean iron formation is known from every area of Timiskaming-like sediments. . . .Always it is the same well-banded, lean iron-poor, crumpled siliceous (orginally cherty) interbedded with graywacke, type of deposit. . . . In the later geologic times, the place of the cherty iron formations is occupied by the bedded cherts, which like their pre-Cambrian predecessors are thin-bedded, locally crumpled, interbedded with shaly materials and associated with graywackes and greenstones, and in some cases are somewhat ferruginous. Such is the case with the Franciscan radiolarian cherts, the cherts of New South Wales, the Mesozoic radiolarian cherts of the Alps and the Apennines, the Carboniferous radiolarian cherts of south Wales. . . . .The writer knows of no thick section of greenstones and graywackes without interbedded cherts. . . .The younger bedded cherts associated with the geosynclinal graywacke-greenstone complex contain Radiolaria which most certainly indicate marine origin. (1943, p. 957-959)

With this background of knowledge it is virtually certain that the Tillman graywackes and bedded cherts, together with the spilitic basalts of the Navajoe Mountain Group, are geosynclinal sediments of great thickness, marine origin, and probably of much vaster distribution than can be demonstrated from present well-sample information in Oklahoma. One deterrent to obtaining direct additional information where it is most needed—between the Wichita Mountains and eastern Arbuckle Mountains—is the great depth and substantial thickness of Carlton rhyolite, beneath which the graywackes probably have their maximum thickness but are much too deep to be penetrated by drilling. This is the area of greatest downwarping and structural deformation in southern Oklahoma. It also is the site most likely to contain geosynclinal sediments. That graywackes are present in this elongate tract is suggested by seismic data near the Stanolind 1 Perdasofpy well, for below Carlton rhyolite and Navajoe Mountain basalt is a stratified or stratiform sequence at least 20,000 feet thick (fig. 19). Although the kind of rock in the lower sequence is unknown, it is strongly suspected that it is Tillman graywacke.

The downfolded belt coincides with the deepest part of what is here called the Southern Oklahoma geosyncline. It occupies a narrow trough north of the Wichita Mountains, extending southeastward for a known length of at least 300 miles and containing 30,000 to 40,000 feet of Paleozoic sediments above the Carlton rhyolite. Rhyolite, basalt, and graywacke of Early Cambrian(?) and Middle Cambrian (?) age, with a thickness of some 25,000 feet, are believed to underlie the younger sediments and to have filled the first or earliest part of the sinking trough. The southeastward extent of the trough is unknown because the meta-graywackes are concealed in Love and Marshall Counties beneath the facies of the Ouachita fold belt (pl. I). However, the meta-graywackes doubtless extend southeastward well beyond this limit, and in northern Texas and northern Louisiana they are possibly the first sediments of the Ouachita Mountains system. If the graywacke belt extends still farther eastward, it conceivably could be contiguous with the Early Cambrian sediments of the Appalachian geosyncline. Such contiguity would indicate that in Early Cambrian time the Appalachian, Ouachita, and Southern Oklahoma geosynclines formed a single trough. This hypothetical trough would have been circumcratonic in the Appalachians and through the Ouachita fold belt, but in southern Oklahoma it would have been a sharply defined intracratonic unit developed within a sag on a basement floor of granitic rocks 1,050 to 1,350 million years old.

Correlation with northern Texas.—The graywackes of Tillman County have direct equivalents across Red River in Texas. Seven wells clustered in Wichita and Archer Counties and in western Clay County are characterized by meta-graywacke and meta-arkose (Flawn, 1956, pl. 1). As mapped and described by Flawn, these rocks are part of the Red River mobile belt, which consists of various metasediments that have been intruded by diorite, granodiorite, quartz diorite, and granite.

Mapping in southern Oklahoma for the present investigation indicates, however, that the rocks of the Red River mobile belt south of Red River are divisible into two different petrologic suites. The easternmost part of the belt contains granite, several kinds of gneiss, and hornblende-, biotite-, sillimanite-, and garnet-bearing schists. Most of the metamorphic rocks are of high rank, and the associated granites have been isotopically dated at 1,050 million years. This suite is therefore placed by us in the Eastern Arbuckle Province. Its western boundary extends diagonally through Clay County, Texas, into and across the southern part of Jefferson County, Oklahoma (pl. V).

The suite of high-rank metamorphic rocks and granite is bounded on the west, in central Clay County, by a contrasting suite of meta-graywackes and meta-arkoses, here considered to be equivalent to the Tillman Group of Oklahoma. They are distinguished by a notably lower metamorphic rank. Accordingly they are believed to be considerably younger in age, and probably lie unconformably upon the older rocks.

The western part of Flawn's Red River mobile belt also is distinguished by various gneisses and schists, and by several kinds of diorite. Two isotopic ages recently determined from rocks of this segment give dates of 1,320 and 1,400 million years (Wasserburg and others, 1962). This information supports the contention that the eastern and western parts of the belt are older and more metamorphosed than the graywackes and arkoses in the central part.

Under the interpretation outlined above, the Tillman metasediments extend from southwestern Oklahoma into northern Texas (pl. V). They form a northwestward-trending elongate segment which corresponds closely in strike to the deep part of the Southern Oklahoma geosyncline. Both segments doubtless are connected in Oklahoma, but they are separated along Red River in the Jefferson County area by a low-lying mass of 1,050-million-year-old rocks. Although graywackes probably were deposited in that area as well, they have been removed by two periods of uplift and erosion, first in pre-Upper Cambrian time and later in Pennsylvanian time.

In addition to its known distribution in Tillman County and in adjoining parts of northern Texas, graywacke probably underlies the vast elongate area of Carlton rhyolite that trends northwestward across southern Oklahoma (pl. V). The total dimensions of this tract are not less than 100 miles wide and 300 miles long. The southeastward extension of graywacke beneath the Ouachita fold belt is unknown, but probably is much greater than the 300-mile length that can be directly inferred.

Sources of sediments.—Clastic sediments of the Tillman Group are graywacke, shale, arkose, and quartzose sandstones. They have been derived by erosion of older igneous and metasedimentary rocks that bordered the elongate depositional basin. Much of the sand-sized clastic sediment originated from granite or granodiorite, for the most common grains in the Tillman graywackes and arkoses are quartz and alkali feldspars, generally proportioned in subequal amounts.

Perthite, orthoclase, microcline, and oligoclase are the only feldspars that occur in significant quantity. Microcline is comparatively rare in Oklahoma but is common in Clay and Wichita Counties, Texas (Flawn, 1956, p. 136-137, 201-202). The scarcity of microcline in the sedimentary strata of Oklahoma is an indication that the rocks bordering the depositional trough on the northeast made no important contribution of sedimentary materials. The Eastern Arbuckle Province granites of the northeastern area invariably contain abundant microcline, and therefore this area must have been topographically so low that it was unable to provide sandy sediment. Just as in the development of geographically similar geosynclines (Appalachian-Ouachita belt), the principal source area lay southward and eastward, away from the craton.

The probable source rocks are in Texas and are chiefly those of the Texas craton, together with some contributions from the eastern and western parts of the Red River mobile belt. A substantial portion of the medium-sized clastic grains in southern Oklahoma evidently was brought in from the granodiorites of the Texas craton in Donley and Hall Counties of the Texas Panhandle, as the rocks there are

rich in alkali feldspar yet contain no microcline (Flawn, 1956, p. 151-154, 165).

The fragments of quartzite and phyllite locally present in the graywackes are derivable from the Red River mobile belt, whereas the grains of chert probably came from silicified sediments or from volcanic rocks of the Panhandle volcanic terrane. Subrounded elongate grains of phyllite, some with a length-to-width ratio as high as 3 to 1, have survived transportation in spite of their fragile character.

Source areas of the Meers Quartzite are more obscure, although to judge from the high quartz and low feldspar content of the rock, it has been derived mainly from older sandstones. No extensive tract of such sandstones is known south or west of the Wichita Province. Perhaps the source is in the Precambrian quartzites of central Kansas (Walters, 1946), or in some similar sediments that are now deeply buried in northwestern Oklahoma.

To summarize, the clastic sediments of the Tillman Group were poured into a northwestward-trending basin that was bordered on the south by highlands of granitic rocks, metasediments, and volcanic rocks. Only minor contributions were received from the north. From the textural composition of the graywackes—particularly their high content of clay matrix—it is clear that the sediments were deposited in quick succession, with little time for sorting or winnowing. Turbidity currents may have played an active role in transportation and deposition. Such sediments are typical of rising highlands bordering a sinking trough, the rate of sediment supply being a governing factor in the rate of subsidence of the depositional trough.

EASTERN ARBUCKLE PROVINCE

General Features and Age

The oldest rocks in southern Oklahoma are predominantly granites and allied intrusives of Precambrian age, which crop out over an area of 150 square miles in Johnston and Atoka Counties, in the eastern part of the Arbuckle Mountains. Together with their subsurface equivalents, they compose the Eastern Arbuckle Province, the name being taken from the outcrop area. They constitute the older massive basement rocks of the craton and as such are wholly different in origin, lithology, and structural evolution from the much younger geosynclinal sediments, flows, and intrusives of the Wichita Province (table 16).

EASTERN REGION

The principal region of Eastern Arbuckle Province rocks is a tract covering 2,700 square miles in the eastern part of the map area shown in plate I. The same kinds of rocks probably extend eastward, in Bryan and Atoka Counties, beneath the western part of the Ouachita fold belt, and they doubtless continue northward into central Oklahoma. Paleozoic rocks deposited upon this massive cratonic basement are generally thinner than in other parts of southern Oklahoma, and they are characterized structurally by moderate folding accompanied by block faulting (pl. II). Flows and sediments of the Wichita Province are not found upon the granitic floor in the eastern region, presumably because it lay outside the border of the Southern Oklahoma geosyncline, in which the Wichita rocks attained their maximum development. The border itself is defined on plate I as a northwestward-trending linear contact separating massive granites on the northeast from thick flows of Carlton rhyolite on the southwest. Substantial control from outcrops and wells, supplemented by structural and geophysical data, indicates that the line of separation was a basement-rock fault during extrusion of the Carlton rhyolite, the upthrown northeastern block of granites forming a fault scarp against which the rhyolite flows were terminated.

Medium- to coarse-grained pink granite, in part strongly porphyritic, and locally with a gneissoid fabric, is the dominant rock in outcrops and in subsurface of this region. Also present on the outcrop are numerous dikes and sills of diabase, together with less abundant dikes of pegmatite, aplite, and rhyolite. Inclusions of older granites and of biotite-hornblende schist are known. A sample of granite from the Capitol quarry in the Arbuckle Mountains has been isotopically dated from zircon and biotite at 1,350 million years (table 4).

Samples from 19 wells drilled in Bryan, Atoka, Johnston, Pontotoc, and Murray Counties show that the rocks of the Eastern Arbuckle Province in subsurface are granite, diabase, and diorite. Three of the wells in Bryan County had exceptionally deep penetrations. Two of them cut 3,600 to 3,800 feet of basement granites, and a third penetrated more than 11,800 feet, probably a world record for drilling in granite.

The deepest penetration is that of the Phillips 1 Matoy well, in which 11,823 feet of Eastern Arbuckle Province rocks was cut. The coarse-textured pink granite that predominates in the well is injected by numerous sill-like bodies of diabase and biotite-hornblende diorite, each ranging in drilled thickness from 20 to 270 feet.

Altered diorite similar to the diorite in the Matoy well was cored in the Atlantic core hole 2 of southeastern Johnston County and in the Shell core hole 14 of Atoka County, but in all the other wells the principal rocks encountered are granite and diabase. Locally the diabase is exceptionally abundant.

A determination of Rb^{87}/Sr^{87} in biotite of the diorite in the Matoy well gave an age of approximately 1,200 million years (table 4). The granite intruded by diorite in this well is shown by cores to be petrographically indistinguishable from granite at the Capitol quarry, which is 150 million years older. Both granite and diorite are Precambrian, but the diorite is considerably younger and belongs to a different magmatic episode than that of the older granite.

Granite-diorite age relations of the Eastern Arbuckle Province are opposite to those of the Wichita Province, in which diorite and gabbro are older than and intruded by granite. In the Wichita Province the gabbro-diorite body and many of the granite bodies are believed to be essentially concordant injections, emplaced within a small geographical area within a short span of geologic time, whereas in the Eastern Arbuckle Province the intrusions are widely distributed and probably were emplaced intermittently through a time span of several hundred million years. The total range is probably about 300 million years, as a Precambrian granite from Jefferson County in the southern region of the Eastern Arbuckle Province has been dated at 1,050 million years.

SOUTHERN REGION

The second and much smaller region of Eastern Arbuckle Province rocks known in southern Oklahoma is wholly in subsurface along Red River. It is separated from the eastern region by a deep sedimentary and structural basin.

Samples from four wells drilled to basement rock in the southern part of Jefferson County have been examined. Three of them consist of coarse-grained pink granite that is petrographically like that which is widely distributed in the eastern region, and one consists of biotite schist similar to what has been found as large inclusions in granite of the Arbuckle Mountains outcrops. The maximum penetration in Jefferson County is 783 feet, all of coarse-textured granite, in the Sinclair 1 Peterson well. Chiefly on the basis of petrologic similarity, all the basement rocks of southern Jefferson County were mapped unquestionably with the Eastern Arbuckle Province.

Late in the investigations for this report, a core of granite from the Peterson well was isotopically dated in the laboratory of the U. S. Geological Survey (table 4). The calculated age of the granite is 1,050 million years, low in comparison with the 1,200- to 1,350-million-year dates of the eastern region, yet clearly Precambrian and well within the probable age range of granites on a regional cratonic floor. The Jefferson County granite is, nevertheless, the youngest Precambrian rock known in southern Oklahoma. It is the youngest granite in the Eastern Arbuckle Province and doubtless represents a batholith or pluton distinct from that at the Capitol quarry in the Arbuckle Mountains. Perhaps it is allied to the granites at Llano, Texas, which have an age of about 1,050 million years (Tilton and Davis, 1959, p. 196).

We realize that the grouping of 1,350-million-year and 1,050-million-year rocks on the basis of petrographic similarity can be questioned, but the creation of another province or rock group for only four wells in Jefferson County is not justifiable for purposes of this report. Conceptually, however, the rocks here included in the Eastern Arbuckle Province do fit well into a single group because of their similar origin and influence on later structural evolution.

Eastern Arbuckle Province rocks in the southern region have been brought by folding and faulting close to the surface along the strongly uplifted crest of the Muenster arch. These rocks also are known by drilling in northern Texas (pl. V), and they probably extend as a linear band through southern Love County (pl. I). Between the arch and the granite outcrops of the Arbuckle Mountains is the Marietta-Ardmore basin, under which the Precambrian granites are inferred to be deeply covered by geosynclinal sediments and flows of the Wichita Province. Depth to the top of the Eastern Arbuckle Province granite underneath the deepest part of the basin probably is about 10 miles (pl. IV, A-6), and the gross structure of the basin itself is that of a complexly folded half-graben.

By analogy, the ancient granite floor can also be projected westward beneath the Anadarko basin and beneath all rocks of the Wichita Province throughout all parts of southwestern Oklahoma, except where modified by probable anatexis in the formation of the parent Wichita granitic magma.

Petrography

Rocks assigned to the Eastern Arbuckle Province consist mainly of grayish-pink leucogranites and biotite granites. Although all are lithologically similar, they probably were emplaced during at least two distinct batholithic episodes of Late Precambrian time, each contributing to and strengthening the central craton of North America. They are considered to be intrusive bodies of the mesozone, emplaced at moderate depths and later exposed as the result of uplift and deep erosion. None of the overlying Precambrian rocks has been preserved in Oklahoma, but a few inclusions of biotite schist and schistose diorite within the granites suggest that argillaceous sediments with dioritic intrusives were a part of the host-rock framework.

As seen in outcrops and cores, most granites are massive, lacking any suggestion of preferred orientation of their mineral constituents. At a few localities well-defined schlieren have been observed, and in the core of one well (Atlantic 1 Harvey, Pontotoc County) a gneissoid subparallel alignment of biotite has been developed (pl. XV-2). Cataclastic brecciation and the local formation of mylonites are of common occurrence in wells drilled near major faults. Pervading the granites is a subtle incipient metamorphism that results mainly in the formation of crystalloblastic sericite, biotite, hornblende, and epidote.

Virtually all the granites of the Eastern Arbuckle Province are characterized by two feldspars, microcline and oligoclase, which distinguish these rocks petrographically from the perthite-rich low-plagioclase leucogranites of the Wichita Province (table 16).

Injected into the older granite, evidently in the form of sheet-like bodies having a drilled thickness of as much as 270 feet, are diorites rich in hornblende and biotite. Dike rocks that accompany the granites are diabase, simple pegmatites, and aplite. The injection of diabase in two or more periods appears probable.

GRANITES

Early study of igneous rocks in the eastern part of the Arbuckle Mountains by Taylor (1915) and Uhl (1932) revealed that two types of granite are common. Named by Taylor (1915, p. 90-93) the Tishomingo and Troy granites, they were mapped by him in a general way within the relatively poor exposures of the block-faulted region. Noting that the mineral composition of the two rocks was essentially the same, he distinguished the Troy granite by its medium-grained equigranular texture, and the Tishomingo granite by its much greater coarseness and the widespread occurrence in it of pink microcline phenocrysts (pl. XV-1). Both rocks were described as consisting essentially of microcline, plagioclase, quartz, and biotite.

Two additional types of granite and one of syenite were described in the later petrographic work by Uhl. Both workers described dikes of diabase, aplite, and quartz porphyry or rhyolite. Uhl (1932, p. 14-17) also described pegmatite dikes and quartz veins.

Chemical analyses of normal Troy granite and of normal Tishomingo granite are given in table 18. As expected from the mineral composition, the two rocks are chemically similar and are assigned to the same class—1423—in the CIPW classification. With approximately 73 percent silica, 14 percent alumina, and 1.5 percent

TABLE 16.—COMPARISON OF ROCKS IN THE WICHITA PROVINCE WITH THOSE IN THE EASTERN ARBUCKLE PROVINCE

		WICHITA PROVINCE	EASTERN ARBUCKLE PROVINCE
Granitic rocks		*Granites (525 m.y.)*	*Granites (1,050-1,350 m.y.)*
		Normal feldspar is perthite. Free plagioclase generally less than 5%. Most granites contain no microcline; where present locally it is microcline-perthite.	Microcline invariably present, occurring with free plagioclase in a two-feldspar granite.
		Micrographic quartz-perthite intergrowths are common.	Micrographic quartz-feldspar intergrowths are exceedingly rare; occurring locally in traces.
		Riebeckite-aegirite occurs locally in small amount.	Riebeckite-aegirite is unknown.
		Straining (undulatory extinction) of larger quartz grains is inconspicuous to moderate.	Straining of larger quartz grains is moderate to pronounced.
		Gneissic structure absent. Granites are locally cataclastic.	Locally show crudely defined gneissic structure, cataclastic features ranging from microbrecciation to mylonization, and mineralogical changes resulting from incipient metamorphism.
		Emplaced mainly as sills and plutons.	Batholithic environment.
Gabbroic rocks		Raggedy Mountain Gabbro Group: Gabbro-anorthosite. Diorite, age about 535 m.y., contains pyroxene and reddish-brown biotite. Occurs with related rocks of a large gabbro intrusion.	Gabbro and anorthosite are not known within province. Diorite, 1,200 m.y., contains dominant hornblende, olive-green biotite, and no pyroxene. Occurs in granite as dikes and sills locally schistose.
Volcanic rocks		Carlton Rhyolite Group (flows and tuffs). Navajoe Mountain Basalt-Spilite Group (flows and tuffs).	Rock types are not known, although rare dikes of rhyolite porphyry resemble Carlton.
Metamorphic rocks	Lower rank	Tillman Metasedimentary Group (biotitic graywackes). Widely distributed.	Rock type is not known.
	Higher rank	Hornfels and biotite schists are locally developed at contacts with intrusive Wichita granites.	Hornblende-biotite schist in Oklahoma, occurring as inclusions in granite. Schistose rocks containing biotite, garnet, and hornblende are associated with microcline granites and diorites in north Texas.

TABLE 17.—MODAL ANALYSES OF SELECTED ROCKS FROM THE EASTERN ARBUCKLE PROVINCE

		Quartz	Microcline-perthite	Plagioclase	Biotite	Hornblende	Epidote	Sphene	Opaque minerals	Others
OUTCROPS	Tishomingo granite porphyry (normal phase) Capitol quarry C NE 3-3S-5E Johnston County	21.9	49.6	20.4 (An_{12})	2.1		1.1	0.3	0.5	Feldspar alterations (3.7), fluorite, calcite, zircon, apatite, chlorite
OUTCROPS	Troy granite (normal phase) Century Granite quarry SW SW SW 20-2S-5E Johnston County	34.6	37.3	24.4 (An_{13})	2.0		tr	0.3	0.8	Feldspar alterations (0.3), fluorite, calcite, zircon, apatite, chlorite
OUTCROPS	Quartz diorite (phase of Troy granite) SE SW NW 32-2S-5E Johnston County	13.4		58.5 (An_{38})	8.4	15.5	0.3	0.4	1.3	Plagioclase alterations (1.2), chlorite (0.6), apatite (0.1), zircon (0.3)
OUTCROPS	Biotite-hornblende schist (large inclusion in the above rock) SE SW NW 32-2S-5E Johnston County	16.4		44.4 (An_{32})	8.2	21.6	2.6	2.4	3.6	Plagioclase alterations (0.6), chlorite (0.1), apatite (0.1)
SUBSURFACE	Granite core at 4,800-4,807′ Atlantic No. 1 Harvey C NW SE 27-3N-5E Pontotoc County	32	35	20 (An_{13})	5			tr	3	Chlorite (2), sericite, zircon, apatite, calcite
SUBSURFACE	Granite core at 4,663-4,666′ Sinclair No. 1 Peterson NW SW NE 32-6S-6W Jefferson County	39.5	37.0	18.5 (An_{10})	2.8*		1.1	0.2	0.3	Zircon, calcite, hornblende, apatite
SUBSURFACE	Phillips No. 1 Matoy SW NW 24-5S-11E Bryan County — Diorite cuttings at 835-845′			50 (An_{41})	8	34	tr	tr	6	Sericite (2), apatite, zircon, calcite
SUBSURFACE	Phillips No. 1 Matoy — Granite core at 963′	29.1	43.9	24.2 (An_{14})	2.5		0.3	tr	tr	Chlorite, apatite, feldspar alterations, zircon, hornblende, muscovite
SUBSURFACE	Phillips No. 1 Matoy — Diorite core at 1,001′	0.9		20.2 (An_{35})	21.0	55.2		tr	2.3	Zircon, apatite, chlorite, calcite
SUBSURFACE	Phillips No. 1 Matoy — Diabase cuttings at 5,630-5,640′			53 (An_{38})	3				18	Augite (21), chlorite (4)
SUBSURFACE	Phillips No. 1 Matoy — Granite cuttings at 6,500-6,510′	19	41	33 (An_{13})	1		1	tr	tr	Sericite (2), chlorite (2), apatite, zircon
SUBSURFACE	Phillips No. 1 Matoy — Quartz diorite (schistose) cuttings at 11,170-11,180′	9		54 (An_{30})	15	6	5	2	3	Sericite (4), chlorite (2), apatite
SUBSURFACE	Granite cuttings at 1,100-1,130′ Honeymon No. 1 Townsend Bryan County	16.2	42.1	36.2 (An_{10})	1.4*		0.8	0.2	0.2	Feldspar alterations (2.8), calcite (0.1)
SUBSURFACE	Diabase cuttings at 7,430-7,440′ Sinclair No. 1 Everett Unit NE NW NW 1-7S-9E Bryan County			48.2 (An_{52})					4.2	Augite (36.4), olivine alterations (9.1), chlorite (2.1)

* Includes chlorite

calcium oxide, they are notably lower in silica, and higher in alumina and lime, than the Wichita granites. Mainly this is a reflection of the characteristically higher content of oligoclase in granites of the Eastern Arbuckle Province.

In outcrops, the Troy can be distinguished generally by equigranular texture and a grain size of about 2 to 5 mm. In the Tishomingo granite the diameter of most feldspar grains is at least 1 cm, and the largest blocky phenocrysts are about 5 cm, or nearly 2 inches, long (pl. XV-1). These types cannot be identified satisfactorily from the small cutting chips available from most wells. Accordingly, in this report, the terms Troy and Tishomingo are not applied to subsurface granites of the Eastern Arbuckle Province.

Mineral compositions and modal analyses of the Troy and Tishomingo granites are, nevertheless, much like those of the subsurface granites (table 17). The feldspars are microcline and oligoclase. Microcline, constituting 35 to 50 percent of the rock, is generally the most abundant mineral (pl. XVI-1, 2, 3). In part it is strongly perthitic, the albite lamellae being irregularly and conspicuously intergrown. In some thin sections this intergrowth is obscure, yet the microcline probably is cryptoperthite containing submicroscopic albite. Large microcline phenocrysts commonly contain unoriented poikilitically enclosed small grains of quartz, plagioclase, biotite, and even microcline. These grains are particularly abundant near the margins of the host crystal. Oligoclase, mostly An_{12-13}, occurs in all the granites as subhedral grains, generally in amounts ranging between 20 and 30 percent. Zoning is locally noteworthy, particularly near grain margins. Some of these zones and the cores of larger plagioclase grains are conspicuously sericitized. A slight myrmekitic intergrowth with quartz is noticeable in the outer parts of some plagioclase grains. Quartz, the most variable of the essential minerals, ranges mostly from 20 to 35 percent and occurs as irregular interstitial grains. The grains tend to occur in groups that contain as many as eight optical units. Moderate to pronounced straining and undulose extinction characterize the larger quartz grains.

The typical granite contains only biotite as a prominent accessory mineral. The biotite occurs as olive-green strongly pleochroic subhedral grains, generally comprising 2 to 5 percent of the rock. In some cuttings of subsurface granite hardly more than 1 percent of

biotite can be observed. An increase in biotite up to about 10 percent is noted in schlieren, segregations, and in other abnormal phases near inclusions. Normally absent, hornblende becomes common with increasing amounts of biotite.

Flakes of muscovite and small grains of epidote are common. Locally they are of deuteric origin. In some rocks they are associated with hornblende and biotite showing sieve structure, all of them having originated through the process of incipient metamorphism (fig. 18).

Fluorite, apatite, zircon, magnetite, sphene, and garnet are the minor accessory minerals. Purple fluorite occurs as megascopic grains and as cavity-lining crystals in the Tishomingo granite at the Capitol quarry, and at this locality dark-brown wedge-shaped euhedral crystals of sphene can readily be seen with a hand lens. Zircon is sufficiently abundant here to yield a concentrate suitable for isotopic age dating (table 4).

Secondary alteration minerals include chlorite, normally present in all rocks, derived from biotite and hornblende; calcite, the youngest mineral, occurring as irregular replacement masses and veinlets;

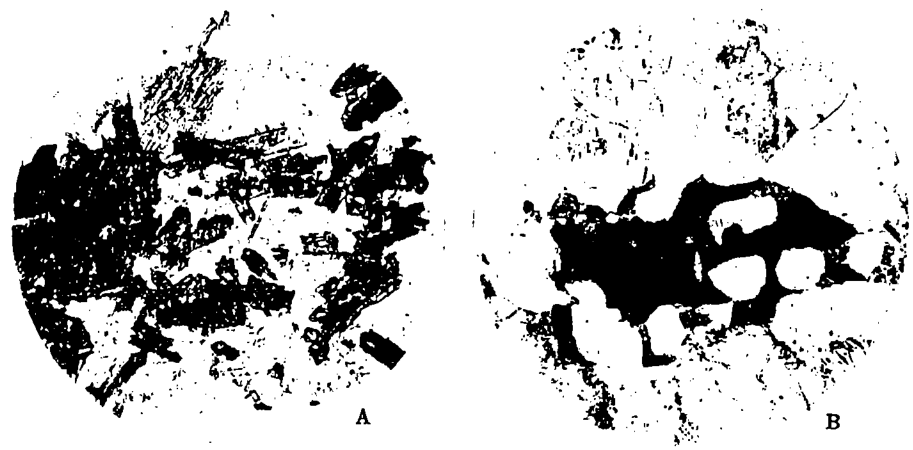

Figure 18. Photomicrographs showing metamorphic features of granites from the Eastern Arbuckle Province.

A. Crystalloblastic epidote (high relief) and muscovite (medium gray) replace the core of a plagioclase crystal (light gray). Phillips 1 Matoy, SW¼ NW¼ sec. 24, T. 5 S., R. 11 E., Bryan County, depth 7,650-7,670 feet. Thin section Br-2-18. Ordinary light. Field diameter: 0.82 mm.

B. Sieve-textured hornblende crystal in granite. Fain-Porter 1 Peters, S½ NE¼ NE¼ sec. 34, T. 2 S., R. 8 E., Johnston County, depth 550-560 feet. Thin section Jn-15-3. Ordinary light. Field diameter: 0.88 mm.

and, finally, the fine-grained alteration products of the feldspars. Among the feldspar alterations are sericite and probably also zeolites and clay minerals. Plagioclase is observed to be more susceptible to alteration than microcline.

Granites of the Eastern Arbuckle Province record at least two periods of alteration. The first and earlier period is shown by the widespread straining of quartz grains, by the local development of mortared boundaries, and by the occurrence of crystalloblastic muscovite, biotite, and hornblende. Deuterically formed epidote, sericite, and chlorite likewise are common. These features probably were not formed simultaneously but are related in origin to the several episodes of granite emplacement. In part they reflect the tectonic environment of granites injected at moderate depths, under moderate load. A generalized dating of these events as pre-Upper Cambrian can be shown by the common occurrence of strained quartz grains in the Reagan Sandstone overlying the granite complex.

The second and younger period is characterized by the cataclastic formation of breccias, mylonites, and bent crystals near major faults of the Arbuckle Mountains. These faults were formed in Pennsylvanian time and can be shown to have stratigraphic displacements up to at least 15,000 feet (Ham, 1955). The brecciation of Pennsylvanian time, being controlled by localized faults, is much less widespread than the earlier Precambrian event. Four wells in Bryan County that were drilled near major faults or actually cut through a fault surface, penetrating deeply into partly brecciated or mylonitic granite (pl. XVI-4), are the Phillips 1 Matoy, California 1 Jones, Sinclair 1 Everett Unit, and Honeymon 1 Townsend.

Brecciation is by no means produced along all faults. The Fain-Porter 1 Peters well, drilled in Johnston County on outcropping granites of the Arbuckle Mountains, penetrated 750 feet of this granite, cut through a thrust fault, and continued drilling in Ordovician sedimentary rocks to a total depth of 1,843 feet. Four thin sections of cuttings taken through the drilled granite sequence show no cataclastic features. The granites instead are characterized by mild straining of the quartz grains and by an excellent crystalloblastic development of biotite, hornblende, and epidote, all related to a Precambrian metamorphic event.

SCHIST INCLUSIONS IN GRANITE

Outcropping granites of the Eastern Arbuckle Province are relatively free from inclusions, although two of large size are known. One is a fine-grained roughly banded dark biotite granite that occurs in the coarse-grained pink Tishomingo granite as an inclusion at least 150 feet in diameter (Uhl, 1932, p. 11-13). With its fine grain size and gneissoid fabric and with anomalously low plagioclase content and high quartz content, it is considerably different from the typical granite of the province. Possibly it is a phase of the host granite, caught in the rising Tishomingo magma as a cognate inclusion.

The other is a fine-grained biotite-hornblende schist inclusion in the Troy granite. It is at least 50 feet in diameter, but the poor exposure does not permit a determination of its actual size. The rock is crystalloblastic, and there is a striking lepidoblastic parallelism of the prismatic hornblende and platy biotite. Andesine, quartz, and epidote are prominent constituents, and the rock has the mineralogic composition of a quartz diorite. The schist is interpreted to be the remnant of a strongly modified host rock, probably diorite, into which the Troy magma was injected. Around the inclusion is a medium-grained massive diorite, evidently an abnormal phase of the Troy granite that has been produced by contamination from the inclusion. At the present time the biotite schist represents the oldest suite of rocks known in southern Oklahoma. A similar schistose quartz diorite occurs deep in the Phillips Matoy well.

Biotite schist occurs in the subsurface of Jefferson County, in the southern region of the Eastern Arbuckle Province. Forty-seven feet of biotite schist was penetrated in the Texas 1 Smart well, NE¼ SE¼ NW¼ sec. 14, T. 7 S., R. 6 W., and there are unconfirmed reports of schist in other wells of the area. The schist contains porphyroblasts of garnet, a mineral not conspicuous in schistose rocks of the Tillman Metasedimentary Group. Coarse-textured plagioclase-rich pink granite occurs in wells north, east, and south of the Smart well, and the granite in one of them (Sinclair 1 Peterson) has been isotopically dated at 1,050 million years. These features place the basement rocks of southern Jefferson County unquestionably in the Eastern Arbuckle Province. Presumably the schist of this area originated in the same manner as did that of the Arbuckle Mountains and occurs as inclusions in granite or as an erosional relict of host rock.

DIORITE

In outcrops of the Arbuckle Mountains, diorite is a subordinate rock type, although in subsurface it locally is a conspicuous part of the Eastern Arbuckle Province. It has been found in Atlantic core hole 2 of Johnston County and in Shell core hole 14 in Atoka County, but most of the knowledge about the diorites of this province is derived from a study of samples from the Phillips 1 Matoy well in northeastern Bryan County, about 18 miles southeast of the nearest granite outcrops of the Arbuckle Mountains.

The Matoy well penetrated 11,823 feet of basement rock, much of it pink granite. In the upper 3,300 feet of the basement rocks, to a depth of 4,000 feet, diorite occurs in abundance as sheetlike bodies or possibly as dikes cutting the granite (pl. XVI-5). Thirteen diorite intrusives are distinguishable upon the basis of the cuttings and electric log (pl. III). The bodies have a drilled thickness ranging from 20 to 270 feet, and the aggregate thickness of diorite is 1,380 feet, or 35 percent of the total rock. Diorite also occurs lower in the well but is much less abundant, and all the bodies are thin. An isotopic determination of Rb^{87}/Sr^{87} in biotite from a diorite core at 1,001 feet gave an age of 1,200 million years (table 4), whereas the granite of the Arbuckle Mountains has been dated at approximately 1,350 million years.

The diorite is a fine- to medium-grained dark rock. Andesine, hornblende, and biotite are the principal minerals, occurring in subhedral grains normally 2 mm in diameter. A part of the andesine is erratically altered to sericite, clay minerals, and possible zeolites. Modal analyses of two thin sections of typical samples from the upper part of the well (table 17) show that hornblende is uncommonly abundant, ranging from 34 to 55 percent, and that biotite ranges from 8 to 21 percent. Titaniferous magnetite with accompanying sphene is a normal accessory mineral, and intergranular quartz is present in small amount. Apatite in needlelike crystals is the most consistently present trace mineral. Well-formed sphene occurs in some samples.

Some of the diorite is crushed and sheared into true mylonite, in which most of the grains are too small for microscopic identification.

The lowest diorite penetrated in the Matoy well (pl. III) is different from the upper samples in that it contains 9 percent quartz and only 6 percent hornblende (pl. XVI-6). Furthermore it is characterized by strong foliation of the femic minerals—biotite, hornblende, and epidote—so that the texture is lepidoblastic and the rock is schistose. This diorite possibly is an inclusion in the granite and therefore older than the diorites in the upper part of the well.

Diorites of the Eastern Arbuckle Province differ petrographically from those of the Raggedy Mountain Gabbro Group in the Wichita Province by their lack of pyroxene and by their content of olive-green biotite, rather than red-brown biotite.

DIABASE

The occurrence of diabase as dikes cutting the granites of the Arbuckle Mountains was noted by Taylor (1915) and Uhl (1932). Commenting on the relative abundance of this rock, Uhl (p. 25-27) wrote:

> Next to the granite diabase dikes are the most abundant rock in the granite area. Although occurring infrequently in the eastern part of the area, they become increasingly abundant towards the west and from Tishomingo northward they make up a considerable percentage of the outcropping rocks. The dikes vary in width from mere stringers to more than one hundred feet, a width of ten to thirty feet being most common. The large dikes are frequently branching. . . .So far as known these dikes cut all the other igneous rocks and are therefore the youngest of the igneous rocks.

Diabase also occurs extensively in subsurface and is conspicuous in all wells penetrating 600 feet or more of basement rock in Bryan and Atoka Counties. Wells containing abundant diabase are State 1 Collins, Phillips 1 Matoy, California 1 Jones, Sinclair 1 Everett Unit, and Honeymon 1 Townsend. A swarm of diabase intrusions cuts the granite of the Townsend well. In it 3,653 feet of Eastern Arbuckle Province rocks was drilled, of which 2,630 is granite and 1,023 feet, or 28 percent, is diabase. The diabase occurs in the form of dikes and sill-like bodies, some of them having a drilled thickness of 150 to 200 feet.

In mineral composition the diabase consists of essential plagioclase, pyroxene or equivalent alteration products, and magnetite (table 17). Hornblende, biotite, olivine, and apatite are the only other common primary minerals. Chlorite, iddingsite, calcite, feldspar alterations, biotite, amphibole, sphene, and quartz are present as alteration or replacement minerals. In the common rocks plagioclase, a calcic andesine or sodic to intermediate labradorite, occurs as subhedral to euhedral laths that are set ophitically in pigeonitic or diopsidic augite. Titaniferous magnetite makes up as much as 18 percent of the rock, occurring as granules, skeletal crystals, and as schiller inclusions within the pyroxene.

Pyroxene alters readily to chlorite, secondary biotite, or an amphibole, normally uralitic hornblende. Plagioclase alters to small sericitic and clay-zeolite masses, and is replaced along veinlets and in patches by calcite.

None of the diabasic rocks in the Eastern Arbuckle Province has been isotopically dated, yet it appears probable that most or all are of Precambrian age and are related to late stages following each of the several episodes of granite intrusion. The freshness of some diabase, however, in relation to altered granite in the same well, suggests that the youngest diabase might be related to the Middle Cambrian Wichita diabasic rocks.

Correlation with Basement Rocks in Adjoining Parts of Texas

The basement rocks of southern Jefferson County extend southward across Red River into Montague, Cooke, and Denton Counties of Texas, where the rocks in about 20 wells have been studied by Flawn (1956). In the eight wells of northern and eastern Montague County, nearest the wells of southern Jefferson County, the prevailing rocks are granite and diabase. Flawn's descriptions of thin sections from cores and cuttings of these wells (1956, p. 178-180) are virtually exact replicas of those of rocks from the Eastern Arbuckle Province. The granites are in part cataclastic and consist of microcline microperthite, oligoclase, quartz, and biotite, in the same proportional ranges as in the granites of the Arbuckle Mountains. One well, the Sztykgold 1 Charles, in penetrating approximately 900 feet of basement rock, alternately cut granite and diabase in a manner clearly analogous to that in the Honeymon 1 Townsend well of Bryan County, Oklahoma. Finally, the only other basement rock described from Montague County is diorite, and it is of the same type as that which occurs in the Eastern Arbuckle Province of Oklahoma. The Texas diorite contains reddish-brown biotite,

however, rather than the brownish-green variety which characterizes the diorite of the Matoy well.

A part of the diorite, as well as some of the granite, exhibits a gneissic fabric.

Southeastward from Montague County into Cooke and Denton Counties, the basement rocks include granite and syenodiorite but are dominantly the following metamorphic types (Flawn, 1956, pl. I):

hornblende-andesine gneiss	hornblende schist
garnet-biotite-quartz-oligoclase gneiss	biotite-garnet schist
biotite-quartz-albite gneiss	sillimanite-biotite schist
metaquartzite	
metagraywacke	

Represented in this suite are rocks of at least three metamorphic grades, and the suite itself has been derived both from igneous intrusions and from sedimentary strata. Granite of the Arbuckle type is definitely associated with the metamorphic rocks and probably is intrusive into them.

The metamorphic rocks in this relatively large area are judged to be a part of the same suite as the biotite schist and diorite schist inclusions in Oklahoma, and all of them are here included in the Eastern Arbuckle Province (pl. V). Being less deeply eroded in Precambrian time than all the areas in Oklahoma, the Cooke County rocks constitute the best record of the complete rock group that serves as a host for the widespread granites.

Isotopic age determinations available from the publication of Wasserburg and others (1962) show that Precambrian rocks with ages ranging from 1,200 to 1,400 million years are common in northern Texas and the Texas Panhandle (pl. V). In other parts of Texas and in New Mexico, rocks included by Flawn in the Texas craton, on the basis of petrographic similarity, have at least three isotopic ages—1,000 million years, 1,200 million years, and 1,300-1,400 million years (Wasserburg and others, 1962, fig. 6). Thus the known age range of rocks in the Texas craton is the same as that of rocks in the Eastern Arbuckle Province.

ROLE OF BASEMENT ROCKS IN THE STRUCTURAL EVOLUTION OF SOUTHERN OKLAHOMA

Introduction

For the purpose of general discussion, the basement rocks of southern Oklahoma are considered to include all rocks older than the Reagan Sandstone, of Late Cambrian (Franconian) age. A regional distinction of this type is justified to the extent that the Reagan Sandstone is at the base of a thick sequence composed exclusively of sedimentary strata that extends throughout most parts of Oklahoma and unconformably overlies volcanic flows, intrusive igneous rocks, metamorphic rocks, and older sediments. In its broadest aspects the distinction is even sharper, for the invasion of Upper Cambrian seas over the central United States, from Texas to Wisconsin and from Colorado to Missouri, is a well-known event of geologic history; and the great unconformity at the base of the Upper Cambrian deposits is one of the most extensive and best known in North America. A common unconformity thus separates Upper Cambrian strata from the underlying floor, and the constituents of the floor are collectively called "basement rocks." In the past these rocks have been assigned to the Precambrian, and for the Continental Interior the term "basement rock complex" has been taken to be synonymous with a Precambrian age.

In southern Oklahoma the basement rocks are neither a "complex" nor are they entirely Precambrian in age. The present investigation shows that the basement rocks, far from being a complex of disorganized units, can be divided into distinct groups that are mappable with reasonable confidence over a region of 20,000 square miles. It can also be demonstrated that some of the basement rocks have a truly Precambrian age of 1,050 to 1,350 million years, whereas others are 500 to 550 million years old and probably are of Early and Middle Cambrian age. Finally, it can be shown that the distribution, thickness, and general character of the basement rocks exert the strongest control upon the structural evolution of the region.

Two major basement-rock divisions have been set forth previously in this report. The older is the Eastern Arbuckle Province, which consists dominantly of massive granite dated at 1,350 million years. Where present at the surface or at shallow depths in the Arbuckle Mountains region and on the Muenster arch, the rocks of this province represent a structurally stable element that has persisted as part of the continental craton since Precambrian time. Overlying Paleozoic sediments generally are thin and only slightly folded.

The younger division consists of basement rocks assigned to the Wichita Province. They are wholly or largely of Cambrian age. In the Wichita Mountains the rocks are mainly gabbro and granite, emplaced as thick sills and irregular plutons. As a result of magmatic injection, the area has been consolidated into a structural unit that has been uplifted as a horst at least twice, once in pre-Reagan time and again during Pennsylvanian time. The remaining groups of Wichita Province rocks are in the shallow Hollis basin and in the great sedimentational trough of the Anadarko-Ardmore-Marietta basin. In this enormous geosynclinal trough the basement rocks consist chiefly of graywackes, flows of basalt and rhyolite, and thin sills of granite. Estimated from geophysical data to be 20,000 feet thick, they represent the first stage of geosynclinal filling. A sequence of Upper Cambrian to Permian sediments as much as 40,000 feet thick was deposited above them in subsequent stages of filling, and the geosyncline collapsed by close folding and uplift during several stages of Late Paleozoic orogeny.

Put into terms of a generalization, the areas of massive basement rocks in southern Oklahoma are characterized by persistent but spasmodic uplift during Paleozoic time, by relative thinness of Paleozoic sediments, and by collapse through block faulting. In strong contrast is the elongate trough of the Southern Oklahoma geosyncline, which is underlain by thick but foldable basement rocks and is characterized by persistent downwarp, total filling in the amount of 60,000 feet, and ultimate collapse by close folding, local overturning, and thrust faulting.

On plate IV is depicted the sequence of geologic events as interpreted from outcrops, wells, and seismic information; and the present configuration of the basement-rock surface into areas of uplift and downwarp is shown by contours on plate II.

MAJOR STRUCTURAL FEATURES OF SOUTHERN OKLAHOMA

Much of southern Oklahoma is cut into large segments that are separated by subparallel northwestward-trending faults of great length (pl. II). Three principal sets of faults can be recognized—southwestern, central, and eastern. These faults participated in the widespread Pennsylvanian orogenies of southern Oklahoma, but some of them follow a much older structural grain established during the time of formation of the basement rocks.

The southwestern set consists of the Burch, Altus, North Fork, and Waurika-Muenster faults. All are downthrown on the southwest side except the Altus fault, which is downthrown to the north into a graben. So far as known from seismic information and drilling, all are high-angle normal faults. Vertical displacement or throw on these faults is variable but generally ranges between 500 feet and 3,000 feet.

The Altus fault has long been known by that name, as it is the fault that forms the northeast boundary of the oil-productive Altus dome, first drilled in 1934. The Burch fault was named by Laing (1963) from the Burch lease, SE¼ sec. 18, T. 1 N., R. 20 W., in southeastern Jackson County. It has been extended northwestward through parts of Greer and Harmon Counties by our mapping for plate II. The hitherto unnamed fault that trends diagonally through central Tillman County into northwestern Jackson County is here called the North Fork fault, the name being taken from North Fork of Red River, which is transected by the fault in T. 1 N., R. 18 W. The Waurika-Muenster fault is the principal fault cutting the Waurika-Muenster arch, along the axis of which basement rock is encountered at relatively shallow depth.

All the faults of the southwestern set cut Pennsylvanian strata and older rocks, including the basement rocks, but none extends to the surface and cuts outcropping Permian sediments. South of the fault system is the Hollis basin* of Harmon and Jackson Counties, and an unnamed basin in the southeastern part of Tillman County. The rocks of this area are characterized by gentle folding, and here the thickness of Paleozoic rocks above the basement probably does not exceed 11,000 feet.

To the northeast is an elongate block, consistently about 30 miles wide, which is divided into two sharply contrasting structural

* Also called Hardeman basin and eastern part of the Palo Duro basin.

elements. The northwestern part is the Wichita uplift, or central Wichita block, in which is located all the outcrops of gabbro and granite of the Wichita Mountains. This segment is a true massif, consolidated by igneous injection. The southeastern segment of the elongate block is characterized by the folded rocks of the Marietta basin, culminating in the deep downfold at Marietta, where rhyolite basement rocks lie at a probable depth of 26,000 feet. On the updip flank of the Marietta basin, near Walters in Cotton County, is the most pronounced positive gravity and magnetic anomaly in southern Oklahoma (Van Weelden, 1934). It perhaps marks the southeastern limit of Raggedy Mountain gabbro in the deep subsurface, below Carlton rhyolite and Wichita granite.

The central set of faults extends continuously for 200 miles across southern Oklahoma, and for a substantial distance beyond into Texas. It is a complex zone of faults, consisting in part of high-angle reverse faults with a net vertical displacement as much as 30,000 feet. The principal named segments are the Duncan-Criner fault, Meers fault, and the Mountain View fault (Harlton, 1963). In addition to the vertical displacement on these faults, it is probable that the Meers fault also has a component of strike-slip movement and is a left-lateral wrench (Moody and Hill, 1956, p. 1224-1225). The general similarity of rocks on opposite sides of the fault shows, however, that the strike-slip component probably does not exceed a few miles.

Rocks of the structural segment between the Meers and Mountain View faults are particularly well known by the drilling of the Stanolind 1 Perdasofpy well (sec. 11, T. 4 N., R. 12 W.), following an intensive program of geophysical research. The results of that investigation have been published (Widess and Taylor, 1959) and the essential information is summarized in figure 19. One of the principal conclusions is that layered rocks below the Reagan Sandstone are probably at least 20,000 feet thick, of which the upper 4,000 feet is known by drilling. These layered rocks are on the margin of the Anadarko basin, and can be projected into deep subsurface below the 40,000 feet of Paleozoic sediments previously known in that basin.

The Anadarko basin itself is a strongly defined synclinal fold lying north of the Wichita block. Its post-basement sediments range in age from Late Cambrian to Permian, but fully half the sediment thickness—20,000 feet—consists of Pennsylvanian strata. Overturned folds and thrust faults characterize the southern margin.

In subsurface the Anadarko basin merges southeastward into a prominent anticlinal fold of eastern Stephens County and northwestern Carter County (pl. II), upon which are many prolific oil fields. Some of these fields, such as Sholom Alechem, Velma, and Graham, are complexly folded and faulted structural features. Continuing southeastward into southeastern Carter County and Marshall County is the steeply folded Ardmore basin, containing at least 30,000 feet of Paleozoic rocks above the Reagan Sandstone. In terms of their structural development and history of geosynclinal filling, the Anadarko and Ardmore basins are virtually a continuous geologic unit.

North of the Ardmore basin is the Arbuckle anticline, the most complexly folded structural feature of the Arbuckle Mountains

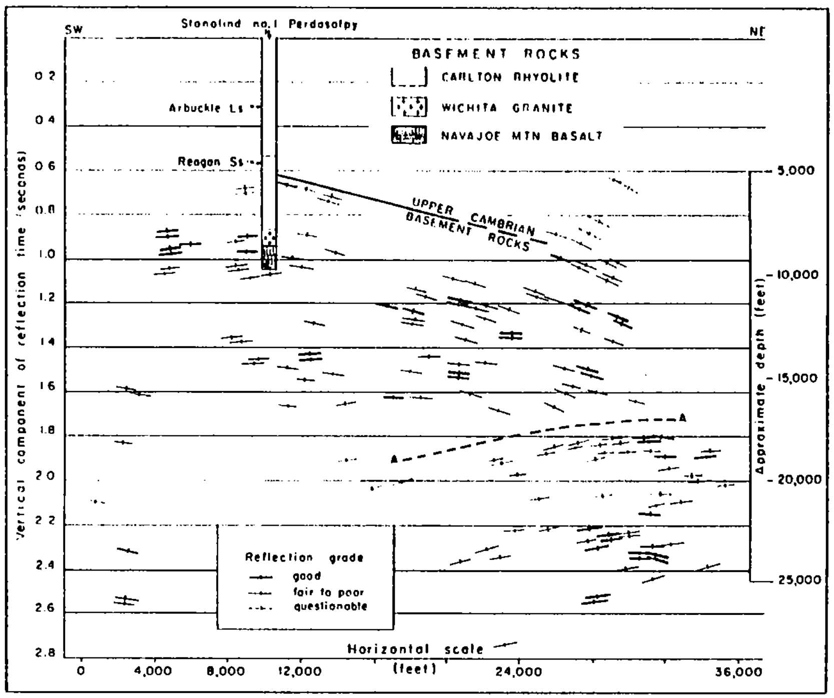

Figure 19. Seismic interpretations at the Stanolind 1 Perdasofpy well, sec. 11, T. 4 N., R. 12 W., slightly modified from Widess and Taylor (1959). The layered character of the basement rocks, including rhyolite, basalt, and probably graywacke, is here defined on the south flank of the Anadarko basin. The discontinuity in dip of the straiform basement rocks at line A-A precludes the possibility of multiple reflections and demonstrates a basement-rock thickness of at least 20,000 feet.

(Ham and McKinley, 1954). A structurally conformable sequence 30,000 feet thick extends from the basement-rock rhyolite of the Arbuckle anticline into the youngest Pennsylvanian beds of the Ardmore basin. Although not generally so considered, the Arbuckle anticline is more closely allied with the Ardmore basin, both stratigraphically and structurally, than it is with other parts of the Arbuckle Mountains. This fundamental relationship is explainable in terms of the basement rocks that underlie each structural province and by the profound influence they exert in molding sedimentational and structural evolution.

The eastern set of faults consists chiefly of those that are prominent in outcrops of the Arbuckle Mountains, and they extend deeply into subsurface well beyond the outcrop area. All trend northwesterly and are subparallel with the other major faults of southern Oklahoma. Chief among them is the Washita Valley fault, which has a conspicuous element of left-lateral movement (Ham, 1956). In the western part of the Arbuckle Mountains it is a steeply southward-dipping reverse fault, and in the subsurface of Bryan County it is a steeply northward-dipping fault. Wells have been drilled in both areas through basement rocks into Ordovician strata.

The Washita Valley fault is the southwest boundary of the Belton-Tishomingo uplift, a stable block underlain by massive Precambrian granite (pl. II). The northeast boundary of the uplift is the Sulphur fault, which has been shown by drilling in Johnston and Atoka Counties to be a reverse fault with steep southwest dip. The Belton-Tishomingo segment is thus bounded by major faults that dip inward beneath it, giving it the form of a downward-tapering wedge.

Massive Precambrian granite extends in subsurface northward from the Arbuckle Mountains outcrops into Pontotoc and Garvin Counties (pl. II). Structures developed upon this basement are only mildly deformed and slightly folded, and the sedimentary column is thin in comparison to those of the Anadarko, Ardmore, and Marietta basins.

Eastern Arbuckle Province

The oldest rocks in southern Oklahoma are massive granites of the Eastern Arbuckle Province, dated at 1,050 to 1,350 million years. They crop out in the eastern part of the Arbuckle Mountains region and are found by drilling to extend northward as the basement rock underneath the Paleozoic sediments of the Hunton-Pauls Valley uplift. They also have been penetrated in the Muenster arch, and they extend throughout most parts of southern Oklahoma, northern Texas, and the Texas Panhandle (pl. V).

Rocks of the Eastern Arbuckle Province are an integral part of a Precambrian terrane that covered much of the interior framework of North America, for studies of isotopic ages (Tilton and Hart, 1963, p. 364) show that igneous and metamorphic rocks 1,100 to 1,400 million years old are present in Texas, New Mexico, Colorado, Oklahoma, Missouri, the northeastern United States, southern Ontario, and southern Quebec.

There is little doubt that during Precambrian time an extensive continental tract was injected by igneous rocks and strengthened into a rigid cratonic block. In southern Oklahoma this block has been a stable element from the time of its formation up to the present, although a major geosyncline lies across it, and locally a younger series of granite and gabbro has been injected into it.

The granites of the Eastern Arbuckle Province, emplaced at moderate depths of the mesozone, were exposed following a long period of Precambrian uplift. Overlying host rocks were stripped away, and an erosional surface of great extent was developed. No additional geologic event is preserved in the record until the deposition upon this eroded surface of clastic sediments of the Tillman Group, presumably latest Precambrian or Early Cambrian in age.

The original extent of Tillman graywacke, arkose, and sandstone can be extrapolated in general terms from present distribution and from certain geologic considerations. A subsurface belt of these sediments 300 miles long and as much as 100 miles wide probably is present in southwestern Oklahoma and adjoining parts of northern Texas (pl. V). The sedimentary sequence was deposited upon a granite floor and later was covered by basalt and rhyolite flows. Locally the cover has been eroded away and the sediments revealed by drilling, but in downwarps such as the Anadarko basin the cover is so thick that no well has been drilled through it. The sedimentary sequence below, however, can be inferred from seismic records, and it appears most likely that clastic sediments of the Tillman Group were originally deposited throughout the entire region. They probably were of greatest thickness in the Southern Oklahoma geosyncline and were spread as thinner deposits over what is now the principal cratonic uplift.

The cratonic uplift of the Eastern Arbuckle Province in southern Oklahoma consists of two segments, the northern one centering around the granite outcrops of Johnston County and the southern one entirely in subsurface on the Muenster arch (pls. I, II, V). They are separated by the northwestward-trending downwarp of the Southern Oklahoma geosyncline. In both segments the Upper Cambrian Reagan Sandstone rests upon Precambrian granite, and all rocks of the younger Wichita Province that may have been deposited or extruded upon the granite surface were removed by erosion before Late Cambrian time. Hence the cratonic segments were being uplifted while thick sediments and flows were accumulating in the downwarp between them. The downwarp took the form of a half-graben, bounded on the north by a fault scarp that sharply separates granite of the Eastern Arbuckle Province from thick flows of Carlton rhyolite (pl. IV).

The patterns of Paleozoic sedimentation and structure subsequently developed upon granite of the Eastern Arbuckle Province reflect persistent crustal stability. Paleozoic sediments are relatively thin, and the segments themselves failed structurally by broad folding and block faulting. Equivalent strata in the geosyncline are thick, and structural failure was generally by close folding (pls. II, IV).

Southern Oklahoma Geosyncline

One of the great structural features of southern Oklahoma is the steeply downfolded belt of Paleozoic sediments that lies northeast of the Wichita uplift and Waurika-Muenster arch, and southwest of the Arbuckle Mountains. It is made up principally of the well-known Anadarko, Ardmore, and Marietta basins, which together have a width of 40 to 50 miles and a length across Oklahoma of 200 miles (pl. II). Estimated depths to the top of the basement-rock surface in the deepest parts of the basin are 30,000 to 40,000 feet, and the thickness of contained Upper Cambrian to Permian sediments ranges between 30,000 and 35,000 feet (pl. IV). A great sequence of stratified and stratiform basement rocks lies beneath the Upper Cambrian unconformity within the basin, and the total basin filling is probably 55,000 to 60,000 feet thick. This important structural unit is here called the Southern Oklahoma geosyncline.

The earliest rocks of the geosyncline are those of the Wichita Province, Late Precambrian or Cambrian in age, which consist of thick clastic sediments, flows of basalt and rhyolite, and intrusions of gabbro and granite mainly in the form of sills. Virtually all the rocks are layered or stratiform, thereby responding structurally and seismically much like bedded sedimentary rocks. As interpreted from geophysical evidence, the sequence of Wichita Province basement rocks on the south flank of the Anadarko basin is 20,000 feet thick. The upper 4,000 feet is known by drilling to consist of flows of rhyolite and basalt, between which has been injected a 600-foot-thick sill of granite. On the south flank of the Arbuckle anticline, on the opposite side of the basin, a similar sequence of rhyolite and granite has been drilled through a thickness of 6,000 feet. The lower part is not certainly known but is strongly believed to be basalt of the Navajoe Mountain Group and graywacke of the Tillman Group.

The development of the Southern Oklahoma geosyncline took place in three stages, the earliest of which, represented by the layered basement rocks, hitherto has been unrecognized. Yet it is now clear that the geosynclinal basin was already established by the beginning of Late Cambrian time, and that the subsequent deposition of Paleozoic sediments within the basin was merely a continuation of the basement-rock pattern.

Even in comparison to the Ouachita geosyncline, the Southern Oklahoma geosyncline is the deepest sedimentational trough in Oklahoma. Termed a zeugogeosyncline by Kay (1951, p. 24), principally on the basis of a knowledge of Pennsylvanian sedimentary rocks, it is now known to be considerably more complex and to have had two earlier stages of filling. In its earliest, or basement-rock, stage it was bounded by faults and filled mainly with graywacke and volcanics, and accordingly the terms taphrogeosyncline (Kay, 1951, p. 60) and eugeosyncline might be applied. This stage ended with the outpouring of thick rhyolites and with general emergence. The second stage was dominated by the deposition of carbonate rocks from Late Cambrian through Devonian time, including limestone and dolomite of the Arbuckle Group (Cambrian-Ordovician), Simpson Group (Ordovician), Viola Limestone (Ordovician), and Hunton Group (Silurian-Devonian). During the second stage, the sedimentary sequence was built up in the Arbuckle anticline to a thickness of 10,000 feet (Ham, 1955, p. 28), and this thickness, as shown in wells, is maintained throughout most of the Southern Oklahoma geosyncline. Hence the second stage of filling could be called miogeosynclinal. The third and concluding stage is marked by the deposition of clastic sediments, Mississippian, Pennsylvanian, and Permian in age, which are 18,000 feet thick in the deepest part of the Ardmore segment and approximately 24,000 feet thick* in the deep part of the Anadarko segment of the basin. A part of the sediment filling was derived from the uplifting Wichita Mountains during Pennsylvanian time, so that at this stage the term zeugogeosyncline would be applicable.

The dominant feature in the development of the Southern Oklahoma geosyncline is the persistence of basinward downwarp throughout a long span of geologic time, during which the geosyncline passed through three distinctive stages without collapse and without premature consolidation. It is probable that the geosyncline is wholly of Paleozoic age, as the youngest sediments are Permian and the oldest deposits—Tillman graywacke—are considered to be Early Cambrian.

In addition to setting a structural pattern for the future development of the basin, the basement rocks of the Wichita Province profoundly influenced the magnitude and intensity of folding that occurred during the several stages of Pennsylvanian orogeny. The formation of closely folded anticlines, with locally overturned limbs, is limited in the Paleozoic rocks of southern Oklahoma almost exclusively to the Anadarko-Ardmore-Marietta basin and to bordering structural segments such as the Arbuckle anticline and the north flank of the Wichita Mountains. All these segments are directly underlain by Carlton rhyolite and therefore are properly a part of the geosyncline.

The role of basement rocks in supplying a foldable platform, instead of an unyielding and rigid base, is apparent even from a casual inspection. Where exposed for study, closely folded anticlines involving thick Arbuckle carbonates, Honey Creek Limestone, and Reagan Sandstone show that the underlying basement-rock rhyolites

* Shell 5 Rumberger well, sec. 16, T. 10 N., R. 21 W., Beckham County.

are structurally conformable, the flows of rhyolite having substantially the same dip and strike as the overlying sedimentary beds. The stratiform rhyolites have yielded by folding in exactly the same manner as the Paleozoic sediments. The localities where such observation is possible include the East Timbered Hills and West Timbered Hills of the Arbuckle anticline, and Blue Creek canyon and Bally Mountain in the Wichita Mountains. At the Bally Mountain section in particular these relations are well shown (fig. 4). The closely folded Criner Hills anticline also is known by drilling to be underlain by rhyolite, although conformable structural relations could not be demonstrated from well cuttings.

It is strongly believed by analogy that the Sycamore Creek anticline, which is a direct southeastward continuation of the Arbuckle anticline, and, like it, is characterized by steeply dipping limbs of Arbuckle limestone, also is underlain by a foldable rhyolite basement. The anticline is exposed in the south-central part of T. 3 S., R. 4 W., adjacent to the Washita Valley fault (Ham and McKinley, 1954). North of the fault, in the Tishomingo uplift, the Arbuckle limestone dips gently westward and is underlain by unyielding granites of the Eastern Arbuckle Province. The exceedingly marked contrast in the kind of folding of the same Arbuckle beds, on opposite sides of a single fault zone, can be reasonably explained only by a difference in character of the underlying basement rock. The interpretation in this instance is so clear that rhyolite is mapped without qualification under the Sycamore Creek anticline, even though no well has been drilled into it.

Two widely spaced deep wells show that intrusive rocks of the Wichita Province probably do not play an important part in the pre-Late Cambrian development of the Southern Oklahoma geosyncline. The Stanolind 1 Perdasofpy, sec. 11, T. 4 N., R. 12 W., located on the common flank between the Wichita Mountains and the Anadarko basin, penetrated approximately 4,000 feet of basement rocks beneath the Reagan Sandstone and found in this sequence a chilled-margin granite sill 600 feet thick lying between rhyolite and basalt. Similarly, the Frankfort 1 Sparks, sec. 32, T. 1 S., R. 1 W., on the southwest flank of the Arbuckle anticline, penetrated 4,500 feet of rhyolite before drilling 1,500 feet of Wichita Province granite. In the Sparks well the granite is interpreted as a sill intruded into the lower part of the Carlton rhyolite and above Navajoe Mountain

basalt or sediments of the Tillman Group. The thickness of these intrusive sills within the Anadarko-Ardmore basin is considerably less than that inferred from outcrops in the Wichita Mountains region, which is judged to be the center of igneous activity. It is furthermore believed that plutonic masses of granite and thick layers of gabbro are absent in the Southern Oklahoma geosyncline, and that the principal rocks are graywacke, volcanic flows, thin sills, and the accompanying small-scale feeders that supplied the magma for the flows and sills.

The deep structural and sedimentational trough of the Southern Oklahoma geosyncline is partly bounded by faults, and some of these faults can be shown to have originated during the basement-rock stage. The eastern segment of the basin, chiefly in Carter, Jefferson, Love, and Marshall Counties, is divided into the Ardmore basin or northern segment, and the Marietta basin or southern segment. Between them is the Criner Hills faulted anticline, yet it is clear that before the formation of this anticline in Pennsylvanian time the two segments formed a single downwarp. At the close of the basement-rock stage, this downwarp is visualized as having had the form of a half-graben (pl. IV), sloping northward off the flank of the Muenster arch and terminating against a high-angle normal fault at the south edge of the Tishomingo uplift. The principal evidence for inferring this fault is that Carlton rhyolite on the basinward side is known by drilling (Frankfort 1 Sparks) to be at least 4,500 feet thick, whereas on the uplifted or northern side the rhyolite is unknown on the outcrop and in wells. Reagan Sandstone lies above basement rocks on each side of the fault, so that the difference in rhyolite thickness must be explained by an event that occurred in pre-Late Cambrian time. We infer that an uplifted segment of Eastern Arbuckle Province granites produced a fault scarp, probably with at least 5,000 feet of net throw, and therefore high enough to contain the flows of Wichita Province rhyolite within the basinward side.

Although downthrown to the south at this stage (pl. IV), the fault was reactivated during Late Pennsylvanian time and, in response to a basinward squeeze, was upthrown from the south, thrusting the Arbuckle anticline over the adjoining structural element. The fault as mapped in the Arbuckle Mountains (Ham and McKinley, 1954) is the Washita Valley fault zone. It coincides approximately with the position of the earlier fault, which marks the boundary separating basement rocks of the Wichita Province from those of the Eastern Arbuckle Province. The strike of the fault is N. 60° W., a directional trend which prevails over most structural features of southern Oklahoma.

While the Ardmore basin segment in the east was first being downfaulted, a complementary and apparently simultaneous movement was taking place in the Anadarko basin segment to the west. Substantial evidence indicates that in pre-rhyolite time a fault having a throw of at least one mile originated in what is now the common flank between the Anadarko basin and the Wichita Mountains. North of the fault, within the ancestral Anadarko basin, a thick series of Navajoe Mountain basalt has been drilled beneath Carlton rhyolite, and graywacke is presumed to lie below the basalt. South of the fault are basement-rock outcrops in the Wichita Mountains, where, as interpreted by the writers, the Carlton rhyolite was poured out over an exposed surface of Raggedy Mountain gabbro (pl. IV). Because the gabbro is coarse textured and was emplaced at depth, it is believed that all rocks originally overlying the gabbro, including sediments and basalt, had been removed by uplift and erosion. The uplift probably was by faulting. Although the position of this basement-rock fault cannot be located more accurately than within six miles, it must be closely parallel to or coincident with the Meers fault (pl. II), which strikes N. 65° W. and is a part of the longest continuous fault zone in southern Oklahoma.

One of the more interesting conclusions of the entire investigation is that the Southern Oklahoma geosyncline originated in basement-rock time and that the bordering faults associated with the first phase of basin filling guided the structural patterns of Late Paleozoic time.

WICHITA BLOCK

As here defined, the Wichita block is a region covering approximately 2,500 square miles in southwestern Oklahoma. It is dominated by intrusive igneous rocks, characterized by uplift and deep erosion, and is bounded on two sides by basinal downwarps. Granite and gabbro crop out over an area of 300 square miles in the structurally highest parts of the uplift, and the remaining part is covered by a veneer of Permian clastic sediments. It is the only

region wherein thick sills and intrusive plutons of granite are known to be associated with a thick-layered body of gabbro, and the conclusion is reached that the Wichita block is the focal point of intrusive activity as well as the most strongly consolidated structural element of southwestern Oklahoma.

The sedimentary framework.—Sufficient surface and subsurface information has been accumulated to permit the interpretations set forth in plate IV. The earliest stage that can be reasonably deciphered is the deposition of clastic sediments upon an eroded floor of massive granites, presumably assignable to the Eastern Arbuckle Province. At this early stage the record is so incomplete that only broad generalizations can be made. It is nevertheless apparent that the deposition of graywacke and sandstone preceded the emplacement of gabbro and granite in the Wichita Mountains, for quartzite inclusions are found in both types of rock, and graywackes are definitely intruded by granites and converted into hornfels. The only point in doubt concerns the thickness and original distribution of the sedimentary sequence. Certainly it must have been thick enough to serve as the host rock for a body of basic magma that crystallized into coarse-textured gabbros, and this generalization places the order of magnitude approximately at 2 miles or more. A clastic sequence of such thickness must also have substantial geographic distribution, and probably would extend well beyond the area in Tillman County, where it is known to be present. With the seismic knowledge that layered rocks are present below Reagan Sandstone to a depth of 20,000 feet on the north side of the Wichita Mountains uplift, it becomes highly probable that a considerable part of the basement-rock sequence of that area consists of graywacke and associated sediments. The seismic information thus supports the conclusion that the graywacke series (Tillman Group) is both thick and widely distributed, and that under the Anadarko and Hollis basins it is still preserved.

With the establisment of a generalized sedimentary framework, the stage is now set for the injection of basic magma, the first igneous event to have occurred in southern Oklahoma since the formation of the Precambrian granites and diorites of the Eastern Arbuckle Province.

Basic rocks.—The injection of gabbroic magma into a framework of Tillman clastic sediments, presumably at a depth of two miles or more, apparently took place without major structural adjustment. No evidence has been found to indicate strong folding or sharply defined faulting during this stage, nor have reasons been found to explain why the injection occurred in this particular region.

The form of the magma chamber likewise is unknown, although presumably it is lenticular. Because the magma was quiescently intruded into flat-lying sediments, it is reasonable to assume that bedding partings guided the initial passage mainly in a horizontal direction, with the result that the final form was a doubly tapering and probably flat-lying lens. Layered gabbroic rocks—the Raggedy Mountain Group—were crystallized within this chamber.

The horizontal extent of the lenticular chamber is known only to the extent that well control and a few petrologic and structural inferences permit. In Oklahoma and adjoining parts of the Texas Panhandle the known length of the area of gabbroic rocks is 110 miles (pl. V). How much farther this body extends cannot be determined from present knowledge, although in all probability it disappears southeastward in Oklahoma before reaching the deepest parts of the Ardmore and Marietta basins. If present at all in these sharply folded basins, gabbroic rock would probably be in the form of sills so thin that they would not obstruct the development of close folding.

The same kind of reasoning is used to place a northern limit on the gabbro, for the most intensely folded part of the Anadarko basin lies just 15 miles away from gabbro outcrops in the Wichita Mountains. Between the two areas no wells have penetrated gabbro, yet it probably extends into the edge of the Anadarko basin as a wedge that tapers gradually and finally disappears.

The known southern limit of gabbro is defined by two wells in northernmost Tillman County, in each of which the gabbro is abnormally fine grained, as though the edge of the intrusion is near.

If the probable geographic dimensions of the Raggedy Mountain Gabbro Group are taken as 40 miles wide and 125 miles long, they would coincide approximately with the region of maximum uplift of the Wichita block, so that the form of the gabbro intrusion has helped in determining the form of the later structural block.

The extrusion of basalt while gabbro was consolidated at depth can be inferred from general geologic relations. A sequence of

basalt, spilite, and altered palagonite tuff approximately 1,000 feet thick has been drilled on the north flank of the Wichita Mountains, and a sequence of basalt and andesite at least 850 feet thick is known on the south flank. No well has been drilled deep enough to penetrate through the basalt and thereby establish its full thickness, but again it can be inferred, for reasons outlined above, that graywacke and gabbro lie beneath the Navajoe Mountain Basalt-Spilite Group. Both basalt and gabbro are younger than the Tillman sediments and older than the Wichita granites, so that the basic rocks are certainly of the same general age, and they probably are contemporaneous. The basalts, however, were soon removed by uplift and erosion of the central Wichita block, and accordingly they exert practically no influence on the subsequent tectonic evolution of this structural segment.

Silicic rocks.—Before the beginning of the second stage of igneous activity in the Wichita block—that concerned with the emplacement of granites and the extrusion of rhyolites—the region was subjected to a period of faulting during which a central horst was formed. As inferred from the best control available, the horst block was 25 miles wide and was bounded by high-angle normal faults (pl. IV). The uplift was of the order of 2 miles or more. It was sufficient, upon erosion of the fault block, to result in removal of the basalt and graywacke and in the exposure of the deeply emplaced gabbro. Extrusions of rhyolite then covered this eroded surface. The time of faulting is pre-rhyolite and post-basalt, and probably is of Middle Cambrian age.

Large-scale faulting during this period was not confined to the Wichita Mountains region, for a normal fault of similar magnitude was formed in pre-rhyolite time between the Tishomingo element of the Arbuckle Mountains and the adjoining Ardmore basin.

The period of pre-rhyolite and pre-granite faulting hitherto has been unrecognized, yet the faults evidently affected a large region of southern Oklahoma and were of great significance in establishing a lineation for future structural evolution. Also implied is an epoch of erosion and hiatus between the gabbro-basalt groups and the rhyolite-granite groups, from which it follows that the rhyolites and granites are probably not differentiation descendents of a parent gabbroic magma.

Whereas the Tillman sediments and Navajoe Mountain basaltic rocks are judged to be dominantly marine, the younger rhyolites were extruded upon the land surface in various nonmarine environments. The flows and welded tuffs of the Carlton Group were built layer upon layer over an irregular but probably subdued topography while well-stratified tuffs and fine-grained agglomerates were deposited in fresh-water lakes. The widespread change from marine to nonmarine deposition is further confirmation of the hiatus and unconformity proposed above on the basis of structural interpretations.

The thickness of the Carlton Rhyolite Group in Oklahoma is known to be at least 3,600 feet at Bally Mountain in the Wichita Mountains (fig. 4) and 4,500 feet in the Frankfort 1 Sparks well on the southwest edge of the Arbuckle anticline (pl. III). At each locality the top is eroded at the unconformable contact with the overlying Reagan Sandstone. The original thickness therefore, was greater than can now be measured and probably was at least 5,000 to 7,500 feet in some areas.

In its wide distribution the Carlton rhyolite is even more impressive. It covers a region of 17,000 square miles. From the Wichita Mountains the flows spread northward and southward, probably being fed by numerous vents and fissures. A thick blanket of rhyolite was laid down from Red River northward to the opposite margin of the ancestral Anadarko basin and eastward to the faulted edge of the Tishomingo uplift, at least as far as Marshall and Johnston Counties. The magnitude of this volcanic field of silicic lava and pyroclastics is without comparison in the geologic history of southern Oklahoma, and at the height of activity the field must have rivaled Yellowstone Park in its display of geysers and hot springs.

Of greater importance structurally was the establishment through vulcanism of a common and persistent roof rock over the eroded edges of basalt, gabbro, and graywacke (pl. IV, W-3). The silicic magma which was the source of rhyolite extrusions was at the same time consolidating at shallow depths of the epizone to form the first phase of the Wichita Granite Group. Successive stages of injected magma, in part rising along previously established faults and fissures, moved into the stratified host rocks and spread horizontally in the form of sills. One horizon particularly favored was the base of the still-warm Carlton rhyolite, along which the magma apparently traveled over wide areas and produced sill-like injected

bodies that can be inferred or determined throughout much of southern Oklahoma. As discussed in a previous section, this relationship can be shown in the Arbuckle anticline, north flank of the Wichita Mountains, the Wichita Mountains Wildlife Reservation, central Cotton County and southwestern Comanche County, and western Greer County. In these areas the roof of the granite sill is rhyolite and the floor of the sill is basalt, gabbro, or graywacke.

Another common form of granite injection is that of irregular plutons. In the western part of the Wichita Mountains as many as three different granites, some of coarse texture and with intrusive outward-sloping contacts, can be observed (Merritt, 1958). Intrusions of this type are doubtless widely distributed within the Wichita Mountains uplift. They are important in strengthening the regional framework into an unyielding rigid mass, for, in addition to their massive bulk, the granite plutons increase the strength of the host rocks by recrystallizing and converting them locally into hornfels. Plutons and thick sills of granite extend southward from the outcrop area of the Wichita Mountains into the subsurface realm of Tillman metasediments, where Wichita-type granite is intrusive into graywacke. This great region of basement rocks, centered in southwestern Oklahoma and including all or parts of Beckham, Harmon, Greer, Jackson, Kiowa, Comanche, and Cotton Counties (pl. II, index map), apparently was made so rigid by the intrusion of Wichita granites that it thereafter responded mainly as a unified structural segment. The shallow Hollis basin was subsequently developed upon Tillman metasediments in the southern part of the region, and the central Wichita block was again uplifted by faulting in Late Paleozoic time, but no part of this consolidated segment was destined to become a strongly folded downwarp such as the Southern Oklahoma geosyncline, in which plutonic granites are presumably absent.

With the injection of the Wichita granites and the extrusion of Carlton rhyolite, during a period dated at 500 to 550 million years ago, and presumably during Middle Cambrian time, all igneous activity in southern Oklahoma came to a close. Igneous rocks are unknown in younger strata of the region, which range in age from Late Cambrian through Permian. The stage of formation of basement rocks also was at a close, after leaving an indelible stamp to guide the structural evolution of younger Paleozoic time.

Post-rhyolite, pre-Late Cambrian folding and erosion.—The unconformity that everywhere lies at the base of the Upper Cambrian Reagan Sandstone represents a time of widespread emergence and erosion. Where the Reagan rests upon extrusive rhyolites of the Carlton Group, the surface already was emergent as land, and a period of erosion had followed the last volcanic effusions. The relation of Reagan resting upon Carlton is found in all parts of the Southern Oklahoma geosyncline, and in this broad northwestward-trending region little or no structural disturbance during the erosion interval can be deduced. In fact it can be demonstrated that at some localities there is little discordance, the flows of rhyolite being structurally conformable with the beds of sandstone. Thus it is clear that the geosynclinal basin, already about one-third filled with basement-rock sediments and flows, merely resumed its subsidence after a short period of uplift.

That part of the Wichita Mountains which had been massively injected by gabbro and granite reacted in an entirely different manner. It was uplifted on the south and the Carlton rhyolite was eroded away, except for one small outlier at the Altus dome in east-central Jackson County. The uplift took the form of a broadly northward-plunging anticline, the axis plunging northward along the Jackson-Tillman county line and into the western part of Kiowa County. The flanks are synclinal, dipping westward under the rhyolite area of western Greer County, and eastward under the rhyolites of Cotton and Comanche Counties (pl. II, index map). The greatest structural relief was in Tillman County, where the oldest basement rocks of the region were exposed.

Although the unconformity at the base of the Upper Cambrian sediments has long been recognized (Taff, 1904), the concepts of pre-Upper Cambrian structural differentiation into a geosynclinal basin with minimum erosion, and a contemporaneously uplifted segment with maximum erosion, are entirely the result of the present basement-rock investigation. Through these investigations it has also been possible to establish an earlier and even greater period of structural disturbance—the pre-rhyolite faulting of the central Wichita block.

EARLY PALEOZOIC INUNDATION

Deposition of Upper Cambrian-Devonian sediments in southwestern Oklahoma is recorded by the presence of carbonate rocks on the north and south flanks of the Wichita Mountains region. In the central area of great uplift and deep erosion they are absent, although it is clear from the marine character of the strata that they formerly extended over the whole region. The point of interest here is that the sequence is about 10,000 feet thick on the north flank and in adjoining parts of the Anadarko basin, whereas the same sequence is less than 5,000 feet thick on the south flank and in the Hollis basin. The difference in thickness is interpreted to be the result of difference in subsidence rates in the two areas, the Anadarko basin or geosynclinal element sinking at about twice the rate of the newly formed Hollis basin. The basement rocks under the Hollis basin had already been extensively eroded during two periods of uplift, and they had been injected and regionally metamorphosed by granites, so that the area was much more stabilized and sank less rapidly than did the Anadarko basin, wherein the basement rocks were thick and the previous record was one of virtually continuous subsidence.

LATE PALEOZOIC OROGENY

Sediments of Mississippian, Pennsylvanian, and Permian age, composed in part of carbonate rocks but mainly of sandstones and shales, surround the Wichita Mountains. Following the depositional patterns established in Early Paleozoic time, these sediments are at least 24,000 feet thick in the Anadarko basin and only 6,000 to 7,000 feet thick in the deepest parts of the Hollis basin. Throughout a long span of Pennsylvanian time the central Wichita block was again being uplifted and eroded. Granite and gabbro were exposed in a wide area, and enormous quantities of arkose and conglomerate were dumped into the Anadarko geosyncline (Edwards, 1959). The uplift originated chiefly by horstlike faulting, the area of maximum uplift and deepest erosion being marked approximately by the present outcrop of gabbro in Kiowa and Comanche Counties (pl. I).

The chief locus of uplift probably was along the Meers fault. This fault had been in existence as a high-angle or vertical fault since being formed during the pre-rhyolite uplift, but it had been given a slight south dip by the northward tilting that preceded the Late Cambrian inundation (pl. IV, W-5). The principal stress direction during Pennsylvanian time was horizontal and normal to the strike of the northwestward-trending faults, but the active movement was upward and northward, parallel to or along the dip of the Meers fault. This movement tilted the central Wichita block to its present position of gentle south dip. At the same time the foreland edge of the Anadarko basin was strongly folded and cut by thrust faults (pl. IV, W-6). The Meers fault is the greatest, probably having a net throw of about four miles.

During this period the Hollis basin was relatively quiescent and structurally inactive. Just as it had received small contributions of sediments in Late Paleozoic time, so was it essentially undisturbed by the Pennsylvanian orogeny. A few en echelon normal faults having maximum throw of 7,500 feet were formed in Jackson and Tillman Counties, separating the Wichita block from the basin, but there is no evidence in this area for thrust faulting or close folding (pl. II).

In its present form the Wichita Mountains region consists of a rigid central block covering approximately 2,500 square miles in southwestern Oklahoma. It is bounded by faults and is made up principally of granite and gabbro, partly exposed and partly covered by a thin layer of Permian clastic sediments. Flanked on the south by a shallow basin and on the north by a major geosyncline, it is a magnificent example of structural control by the distribution, form, and thickness of its basement rocks.

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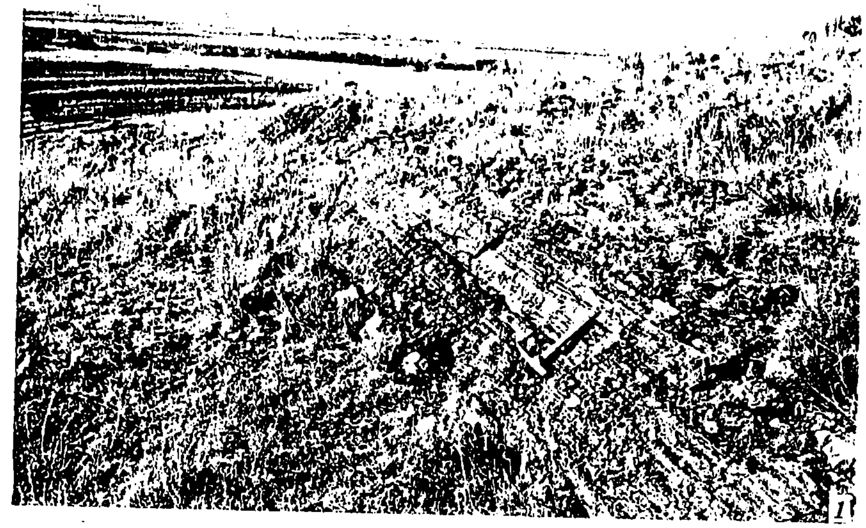
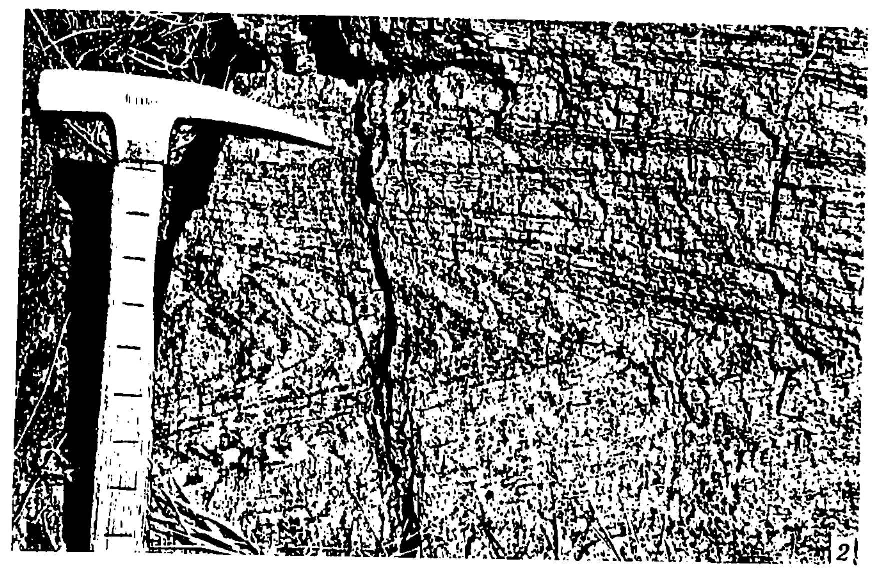
PLATE VI. OUTCROP PHOTOGRAPHS OF CARLTON RHYOLITE

1. Bed of strongly flow-banded rhyolite in upper part of Carlton Group, bed 24 of Bally Mountain measured section, S½ NW¼ SW¼ sec. 26, T. 6 N., R. 14 W. Looking northwest toward Zodletone Mountain on horizon at left.

2. Detail of same, showing parallel and contorted flow banding. Hammer handle is scaled in inches.





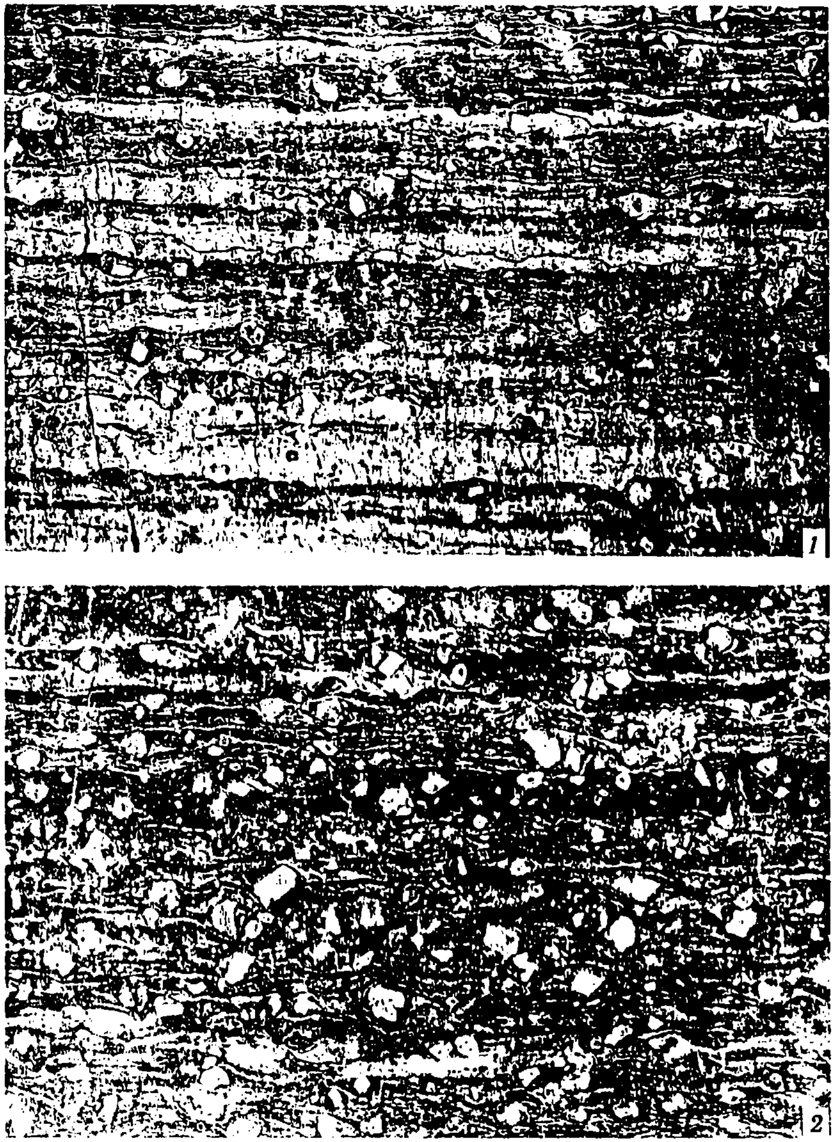


PLATE VII. POLISHED SPECIMENS OF CARLTON RHYOLITE

1. Strongly flow-banded rhyolite porphyry containing phenocrysts of feldspar, x1.1, bed 24 of Bally Mountain measured section, S½ NW¼ SW¼ sec. 26, T. 6 N., R. 14 W. For photomicrograph see plate VIII-1.

2. Strongly flow-banded rhyolite porphyry, x1.5, SW¼ SE¼ sec. 36, T. 1S., R. 1 E., from the East Timbered Hills, Arbuckle Mountains.

PLATE VIII. PHOTOMICROGRAPHS OF RHYOLITE PORPHYRY AND TUFF FROM THE CARLTON RHYOLITE GROUP

1. Rhyolite porphyry, bed 24 of Bally Mountain measured section, S½ NW¼ SW¼ sec. 26, T. 6 N., R. 14 W. Flow bands are contorted around single and composite phenocrysts of plagioclase. Devitrified groundmass of originally homogeneous glass shows iron-rich color bands. Polished specimen shown in plate VII-1. Ordinary light. Field diameter: 7.9 mm.

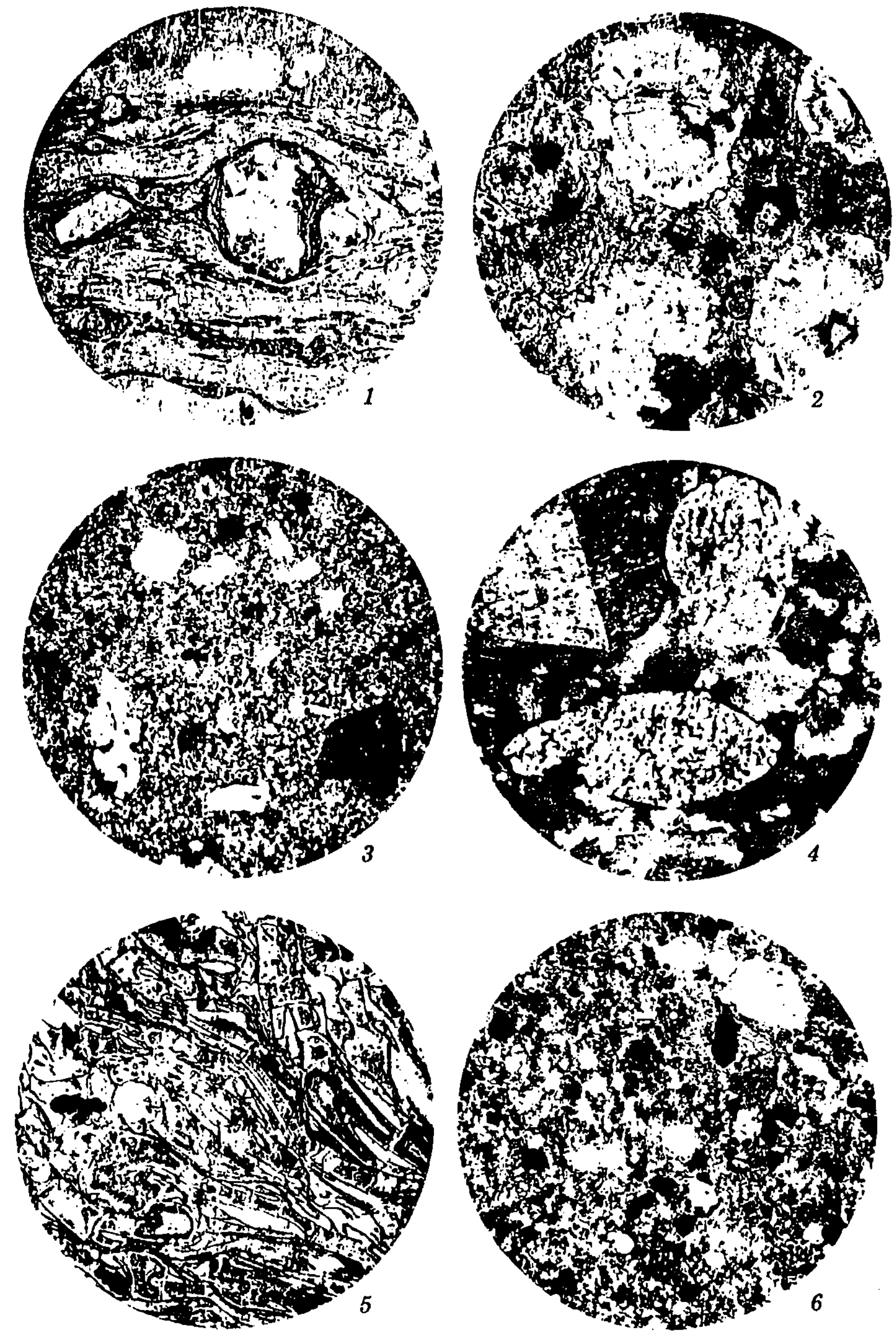
2. Spherulitic rhyolite porphyry, Frankfort 1 Sparks, C SE¼ SE¼ sec. 32, T. 1 S., R. 1 W., depth 8,410-8,420 feet. Pale brown primary spherulites are set in a devitrified perlitic groundmass. Phenocrysts of perthite are not shown. Thin section Mr-1-8. Ordinary light. Field diameter: 2.7 mm.

3. Rhyolite porphyry, beds 5-11 of Bally Mountain measured section (age-dated rhyolite), SW¼ SW¼ sec. 27, T. 6 N., R. 14 W. Phenocrysts of plagioclase (lower left), perthite (lower right), and quartz (upper left) are in a spherulitic groundmass of quartz and feldspar containing abundant iron ore. Polarized light. Field diameter: 7.9 mm.

4. Rhyolite porphyry, Stanolind 1 Perdasofpy, SE¼ NW¼ SW¼ sec. 11, T. 4 N., R. 12 W., depth 7,930-7,940 feet. Strongly rounded and embayed spongy crystals of perthite have delicate flow bands contorted around them. Note at bottom of photograph that devitrification quartz-feldspar units transcend flow lines. Thin section Cm-1-4. Polarized light. Field diameter: 3.0 mm.

5. Welded tuff, bed 23 of Bally Mountain measured section, S½ NW¼ SW¼ sec. 26, T. 6 N., R. 14 W. Contorted and flattened devitrified shards are silicified and outlined by iron ore. Ordinary light. Field diameter: 2.6 mm.

6. Rhyolite tuff, bed 4 of Bally Mountain measured section, SW¼ SW¼ SW¼ sec. 27, T. 6 N., R. 14 W. Subrounded lithic and crystal fragments are in a matrix of iron-rich tuff dust. Crystals include perthite, plagioclase, quartz, and iron ore. All lithic fragments are rhyolite. Polarized light. Field diameter: 2.6 mm.



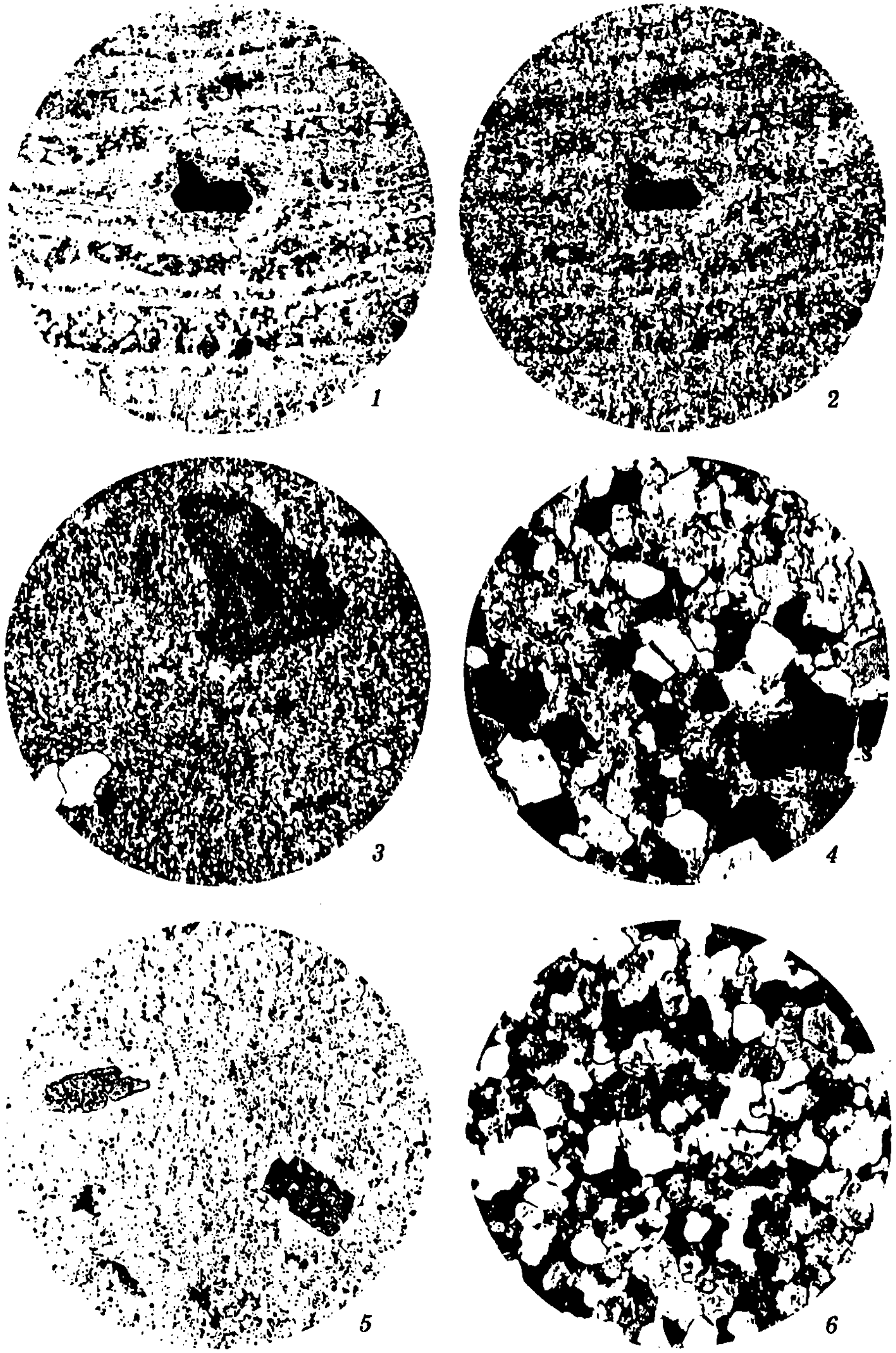


PLATE IX. PHOTOMICROGRAPHS OF HORNFELSIC RHYOLITE

1. Hornfelsic rhyolite porphyry from south shore of Lake Elmer Thomas, SW¼ NE¼ NW¼ sec. 24, T. 3 N., R. 13 W. Flow bands of originally glassy groundmass wrap around a phenocryst, formerly feldspar but now an unoriented mosaic of sericite and iron ore granules. Quartz-rich light-colored layers alternate with sericite-rich dark layers. Thin section is from hand specimen shown in figure 8. Ordinary light. Field diameter: 6.9 mm.

2. Same as photograph 1. Polarized light.

3. Hornfelsic rhyolite porphyry from south shore of Lake Elmer Thomas, N½ SW¼ NW¼ sec. 24, T. 3 N., R. 13 W. Small quartz phenocrysts and a larger relict feldspar phenocryst (above) are surrounded by a quartz-rich reconstituted groundmass. Relict feldspar consists mainly of sericite and included iron ore, the dark core of which is replaced by fluorite. Polarized light. Field diameter: 6.4 mm.

4. Quartz-sericite hornfels, stratigraphically underlying hornfelsic rhyolite porphyry shown in photograph 3 and representing a more advanced stage of alteration. Rock is a granoblastic mosaic of quartz and finely divided sericite in which phenocrysts are lacking. Small grains of high relief in sericite are epidote. Photographs 1, 2, 3, and 4 illustrate differing degrees of rhyolite alteration near an intrusive contact with Wichita granite. Polarized light. Field diameter: 0.82 mm.

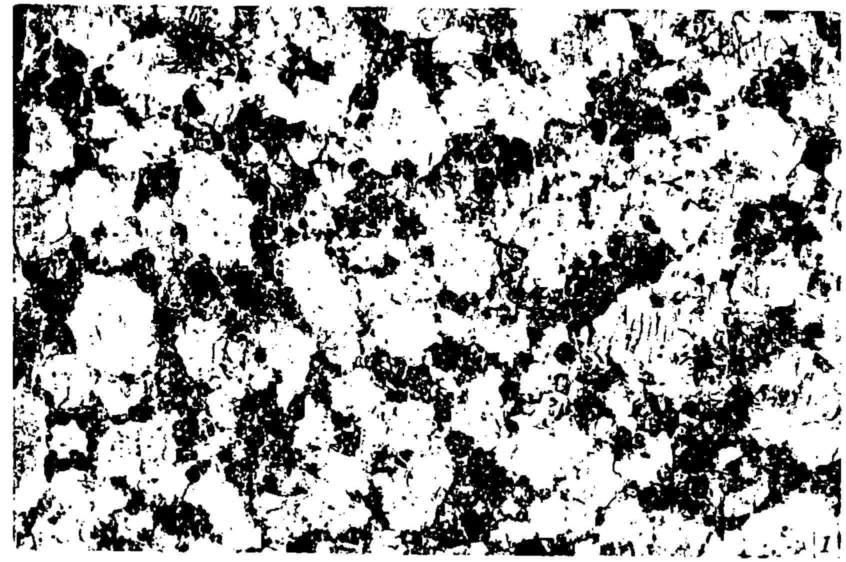
5. Hornblende porphyroblasts in rhyolite hornfels, Gulf 1 Inklebarger, SW¼ SW¼ SW¼ sec. 3, T. 1 N., R. 20 W., depth 2,135-2,136 feet. Strongly pleochroic hornblende crystals with well-defined sieve structure have grown in a granoblastic mosaic derived from a rhyolite porphyry. Thin section Jk-13-1. Ordinary light. Field diameter: 0.78 mm.

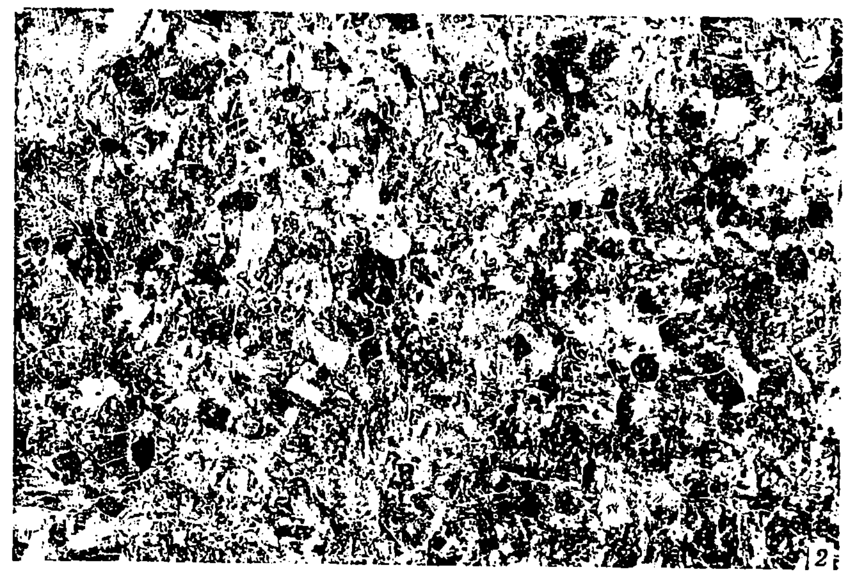
6. Rhyolite hornfels, SE¼ NE¼ NE¼ sec. 18, T. 2 N., R. 16 W. Granoblastic mosaic of quartz and feldspar containing small iron ore granules is from a large xenolith of banded rhyolite in Wichita granite. Polarized light. Field diameter: 0.7 mm.

PLATE X. POLISHED SPECIMENS OF WICHITA GRANITES

1. Reformatory granite, x1.1, Headquarters Mountain, SE¼ SE¼ NW¼ sec. 26, T. 6 N., R. 21 W. This granite, the coarsest of the Wichita Group, consists of large subhedral perthite crystals and smaller anhedral grains of quartz. The rock is nonmicrographic.

2. Micrographic granite porphyry, x3.2, Long Mountain, NE¼ SW¼ NE¼ sec. 14, T. 2 N., R. 18 W. A deep-red fine-grained micrographic granite. Phenocrysts of perthite and smaller quartz crystals are in a groundmass of delicately micrographic quartz and perthite.





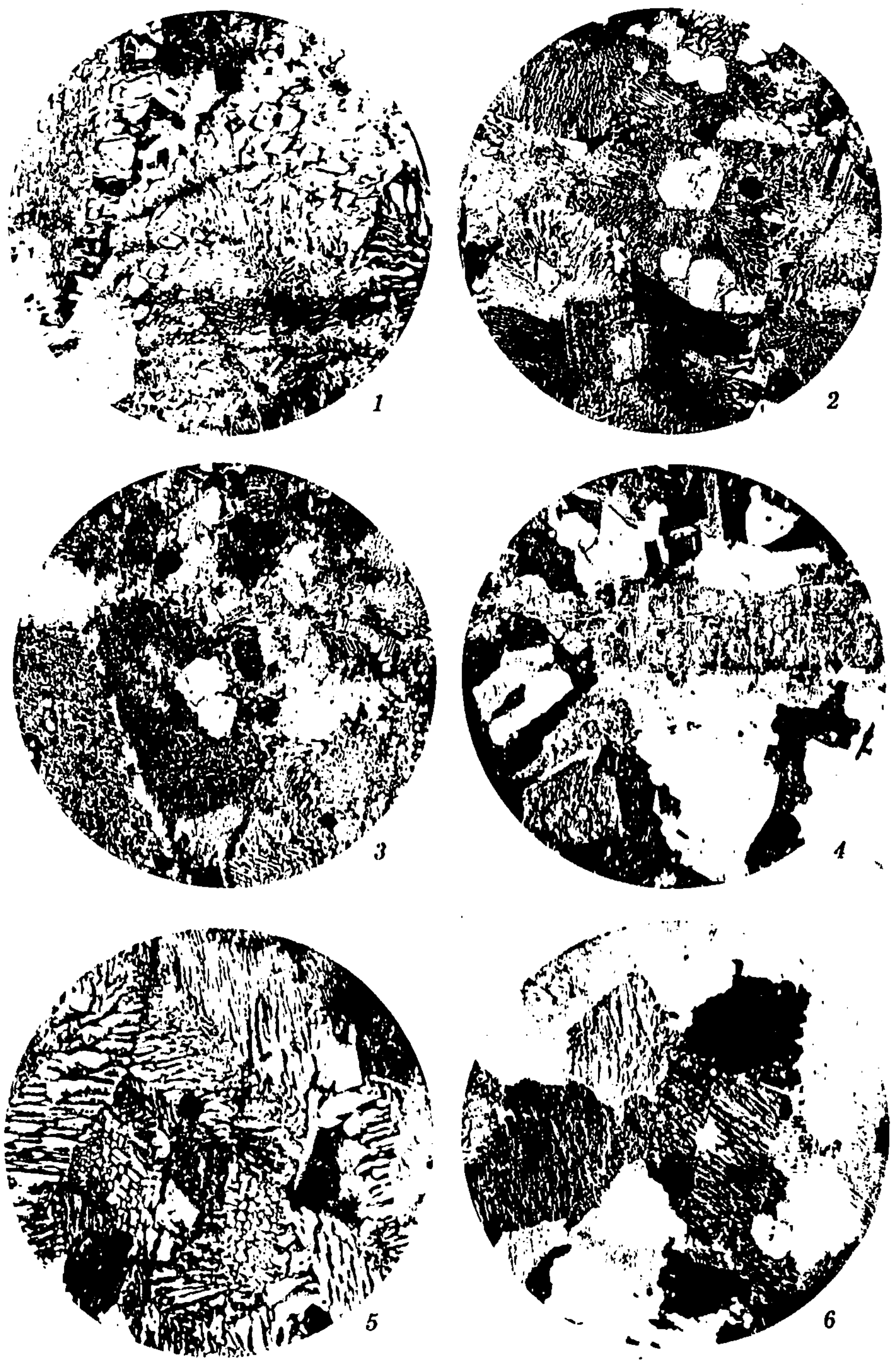


PLATE XI. PHOTOMICROGRAPHS OF TYPICAL GRANITES FROM THE WICHITA GRANITE GROUP

1. Micrographic granite, Mid Kansas 1 Cox, NE¼ SE¼ NE¼ sec. 30, T. 1 S., R. 13 W., depth 1,860-1,890 feet. Delicate intergrowth of quartz and perthite constitutes about 98 percent of this rock. The granite is overlain by the Upper Cambrian Reagan Sandstone. Thin section Cm-36-1. Polarized light. Field diameter: 2.3 mm.

2. Micrographic granite porphyry, Frankfort 1 Sparks Ranch, C SE¼ SE¼ sec. 32, T. 1 S., R. 1 W., depth 12,640-12,650 feet. Delicate micrographic intergrowth is radial to subradial around quartz and feldspar phenocrysts. This granite contains trace amounts of augite and both primary and uralitic hornblende. Thin section Mr-1-24. Polarized light. Field diameter: 2.4 mm.

3. Micrographic granite porphyry, Lippert 1 Howard, SW¼ NW¼ sec. 10, T. 3 N., R. 19 W., depth 984-991 feet. The relatively large perthite phenocryst (left center) is enclosed in a finely micrographic intergrowth of quartz and perthite. This granite intrudes rocks of the Navajoe Mountain Basalt-Spilite Group and converts them into basic hornfels. Thin section Jk-7-2. Polarized light. Field diameter: 2.7 mm.

4. Granite, Sohio 1A Kennedy, NW¼ NW¼ SE¼ sec. 26, T. 1 N., R. 2 W., depth 9,570-9,580 feet. An example of the coarser grained granite found in subsurface beneath thick flows of Carlton rhyolite in the western Arbuckle Mountains area. Compare with photograph 2 above. Thin section Gv-8-18. Polarized light. Field diameter: 2.7 mm.

5. Micrographic granite porphyry, Stanolind 1 Perdasofpy, SE¼ NW¼ SW¼ sec. 11, T. 4 N., R. 12 W., depth 8,340-8,350 feet. A fine micrographic intergrowth of quartz and perthite surrounds small phenocrysts of quartz, perthite, and plagioclase (not shown). This granite is intruded between Carlton rhyolite and Navajoe Mountain basalts. Thin section Cm-1-6. Polarized light. Field diameter: 0.8 mm.

6. Granite, NW¼ NE¼ NW¼ sec. 26, T. 3 N., R. 17 W., typical of the coarser grained outcropping Wichita granites. Hypidiomorphic quartz and perthite comprise 98 to 99 percent of the total rock. Polarized light. Field diameter: 8.1 mm.

Plate XII. Photomicrographs of Rocks from the Navajoe Mountain Basalt-Spilite Group

1. Basalt, Stanolind 1 Perdasofpy, SE¼ NW¼ SW¼ sec. 11, T. 4 N., R. 12 W., depth 9,320-9,330 feet. Ophitic augite contains laths of labradorite. Iron ore is abundant as ragged granules. Portions of the augite have been altered to pale-green chlorite. Thin section Cm-1-13. Ordinary light. Field diameter: 2.4 mm.

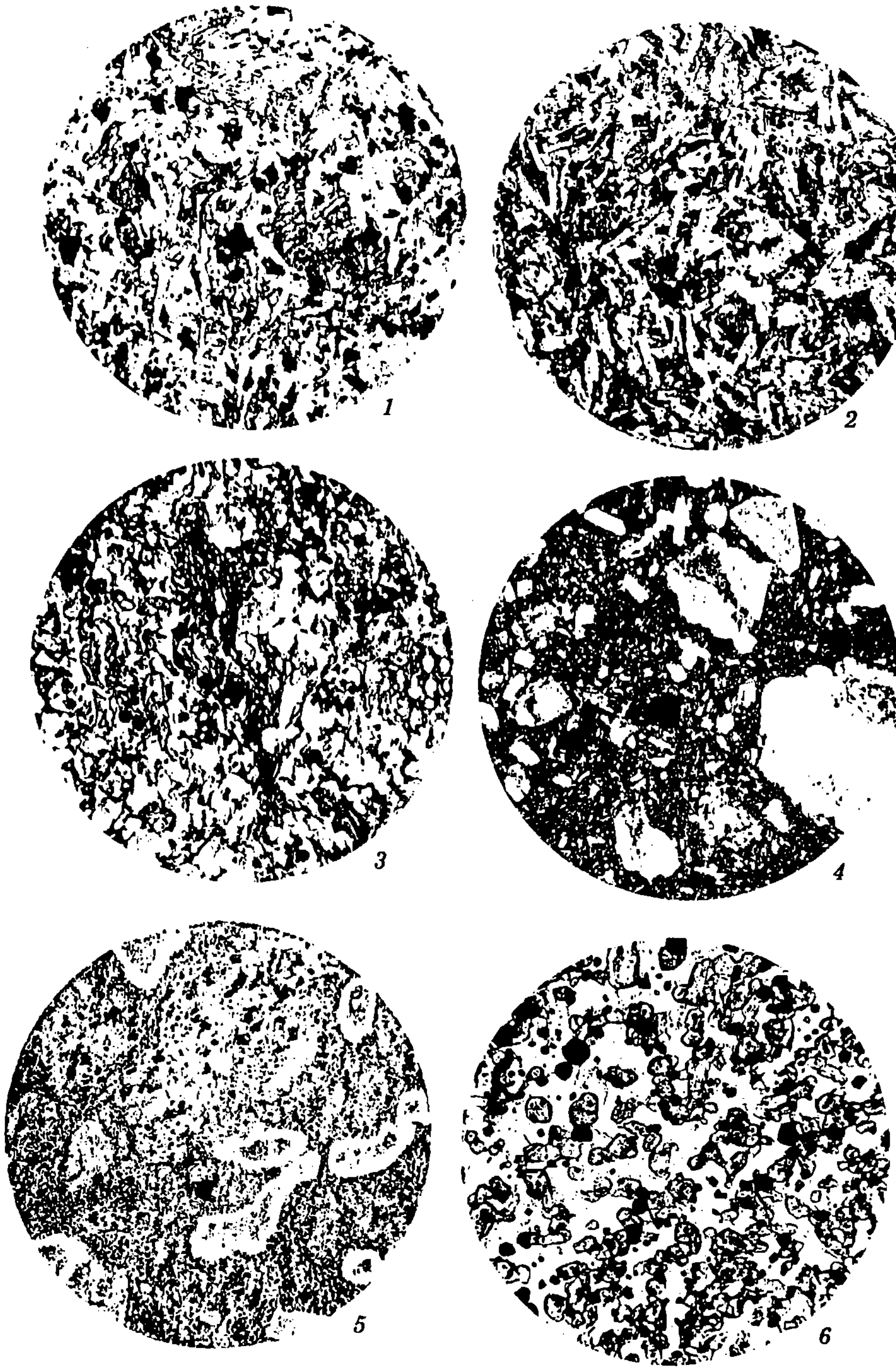
2. Spilite, Cater 1 Williford, C SE¼ NE¼ sec. 24, T. 2 N., R. 9 W., depth 10,026-10,029 feet. Laths of albite (An_8) are set in masses of chlorite and ragged iron ore. No pyroxene remains. Thin section St-1-7. Ordinary light. Field diameter: 2.4 mm.

3. Altered palagonite tuff, Stanolind 1 Perdasofpy, SE¼ NE¼ SW¼ sec. 11, T. 4 N., R. 12 W., depth 9,650-9,660 feet. Devitrified scoriaceous fragments are associated with chlorite, prehnite, zeolites, and iron ore. Thin section Cm-1-19. Ordinary light. Field diameter: 3.0 mm.

4. Andesite porphyry, McCasland and Wilcox 1 Edwards, NW¼ NW¼ NE¼ sec. 9, T. 3 N., R. 21 W., depth 3,810-3,820 feet. Phenocrysts of andesine (An_{38}) are in a groundmass of pilotaxitic feldspar and iron ore. Dark crystal near the center of the photomicrograph is a pseudomorph of pennine-type chlorite after a former mafic mineral. Thin section Jk-4-3. Polarized light. Field diameter: 3.3 mm.

5. Metabasalt porphyry, Sun 1 Wilson, NE¼ NE¼ SE¼ sec. 23, T. 1 N., R. 20 W., depth 3,710-3,727 feet. Relict phenocryst of plagioclase (light area, upper center), partially converted to muscovite, is in an amygdaloidal groundmass. Amygdules are filled with chlorite and lined by quartz. Thin section Jk-18-1. Ordinary light. Field diameter: 2.6 mm.

6. Basic hornfels, Lippert 1 Howard, SW¼ NW¼ sec. 10, T. 3 N., R. 19 W., depth 1,001-1,011 feet. Granules of pyroxene and iron ore are in a granoblastic mosaic of plagioclase containing numerous high-relief needles of apatite. The hornfels is derived from basaltic rocks of the Navajoe Mountain Group. Thin section Jk-7-3. Ordinary light. Field diameter: 0.83 mm.



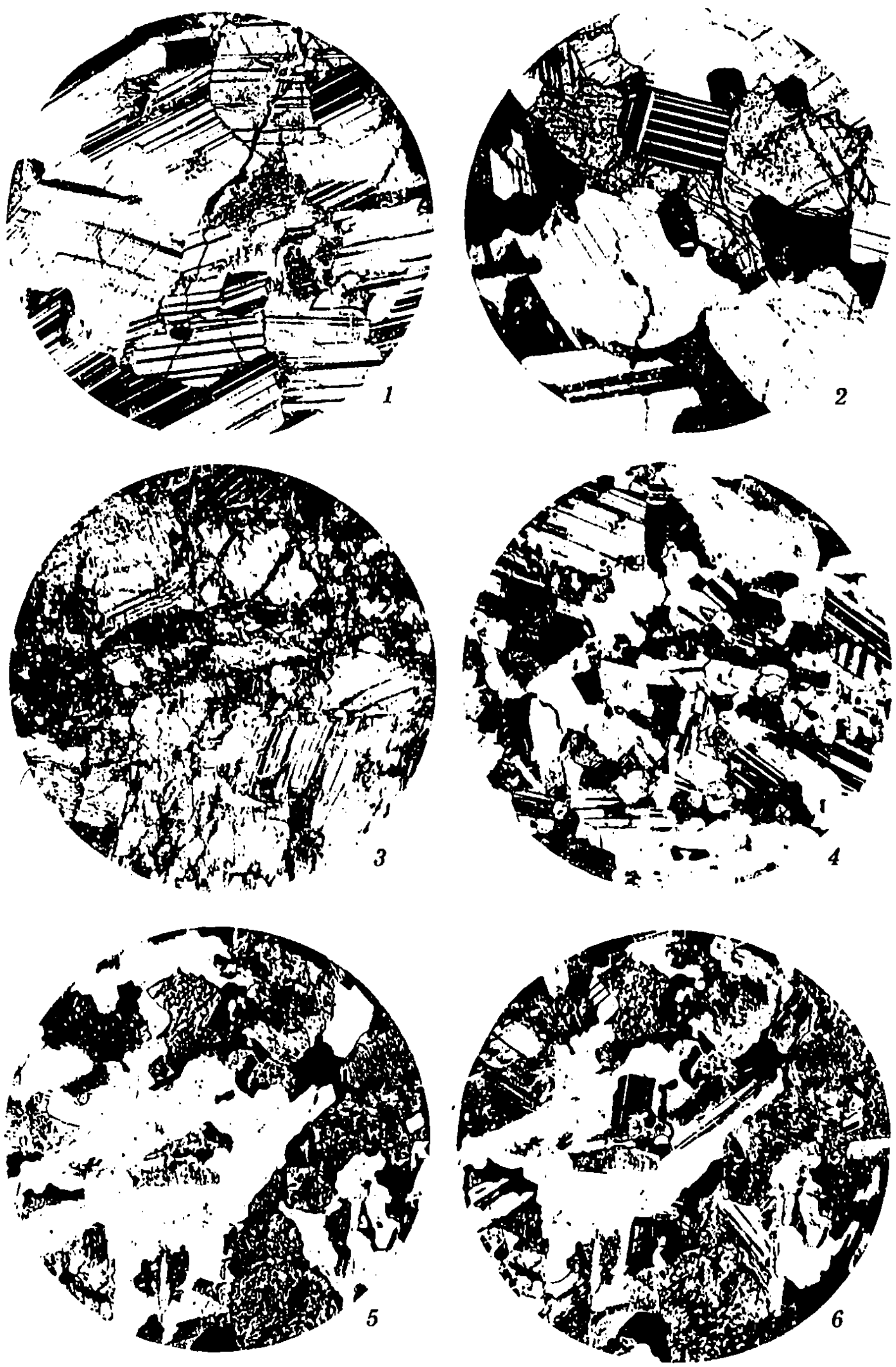


PLATE XIII. PHOTOMICROGRAPHS OF GABBRO AND DIORITE FROM THE RAGGEDY MOUNTAIN GROUP

1. Banded gabbro, Champlin 1 Hieber, SW¼ SW¼ NW¼ sec. 30, T. 8 N., R. 20 W., depth 4,600-4,630 feet. Subaligned laths of intermediate labradorite contain intergranular diallage. Minor zeolitic and sericitic alterations occur along veinlets and in irregular patches. Thin section Wt-3-5. Polarized light. Field diameter: 2.7 mm.

2. Troctolite, Champlin 1 Hieber, SW¼ SW¼ NW¼ sec. 30, T. 8 N., R. 20 W., depth 9,500-9,520 feet. Anhedral olivine crystals (upper) contain cracks filled by iron ore. Exceptionally large apatite crystals are concentrated near the olivine. Locally (not shown) the olivine is converted to iddingsite, and primary red-brown biotite as well as brown basaltic hornblende occur. Thin section Wt-3-13. Polarized light. Field diameter: 2.1 mm.

3. Mylonized anorthosite, Stauffer 1 Mayo, NE¼ NE¼ NW¼ sec. 13, T. 6 N., R. 18 W., depth 1,677-1,704 feet. Crushed and sheared crystals of labradorite are cut by numerous mylonitic linears containing rounded and angular plagioclase fragments. Thin section Kw-25-7. Polarized light. Field diameter: 2.2 mm.

4. Gabbro, Day 1 McElroy, SW¼ NW¼ SW¼ sec. 30, T. 2 N., R. 16 W., depth 500-550 feet. A finer grained example of the gabbroic rocks found near the known southern limit of the Raggedy Mountain Group. The plagioclase is crudely aligned, and some intergranular pyroxene contains schiller-texture iron ore. Thin section Kw-99-1. Polarized light. Field diameter: 2.8 mm.

5. Gabbro, Jo Gail 1 Gilliland, NE¼ NE¼ NE¼ sec. 33, T. 8 N., R. 26 W., depth 2,294-2,538 feet. Labradorite laths are associated with intergranular pyroxene. The pyroxene contains schiller-texture iron ore and is mottled with primary common hornblende. Red-brown biotite and discrete hornblende are also present. The high-relief prism in the lower part of the field is apatite. Thin section Bk-43-4. Ordinary light. Field diameter: 3.3 mm.

6. Same as photograph 5. Polarized light.

Plate XIV. Photomicrographs of Graywacke, Hornfels, and Schist from the Tillman Metasedimentary Group

1. Meta-graywacke, Mid Continent 1 Perry, SE¼ SE¼ SW¼ sec. 30, T. 1 S., R. 16 W., depth 1,490-1,500 feet. Subangular grains of quartz, plagioclase, and minor lithic debris are set in a matrix of quartz and biotite reconstituted from an original clay. Many of the detrital quartz fragments are composite grains. Thin section Ti-18-1. Polarized light. Field diameter: 2.4 mm.

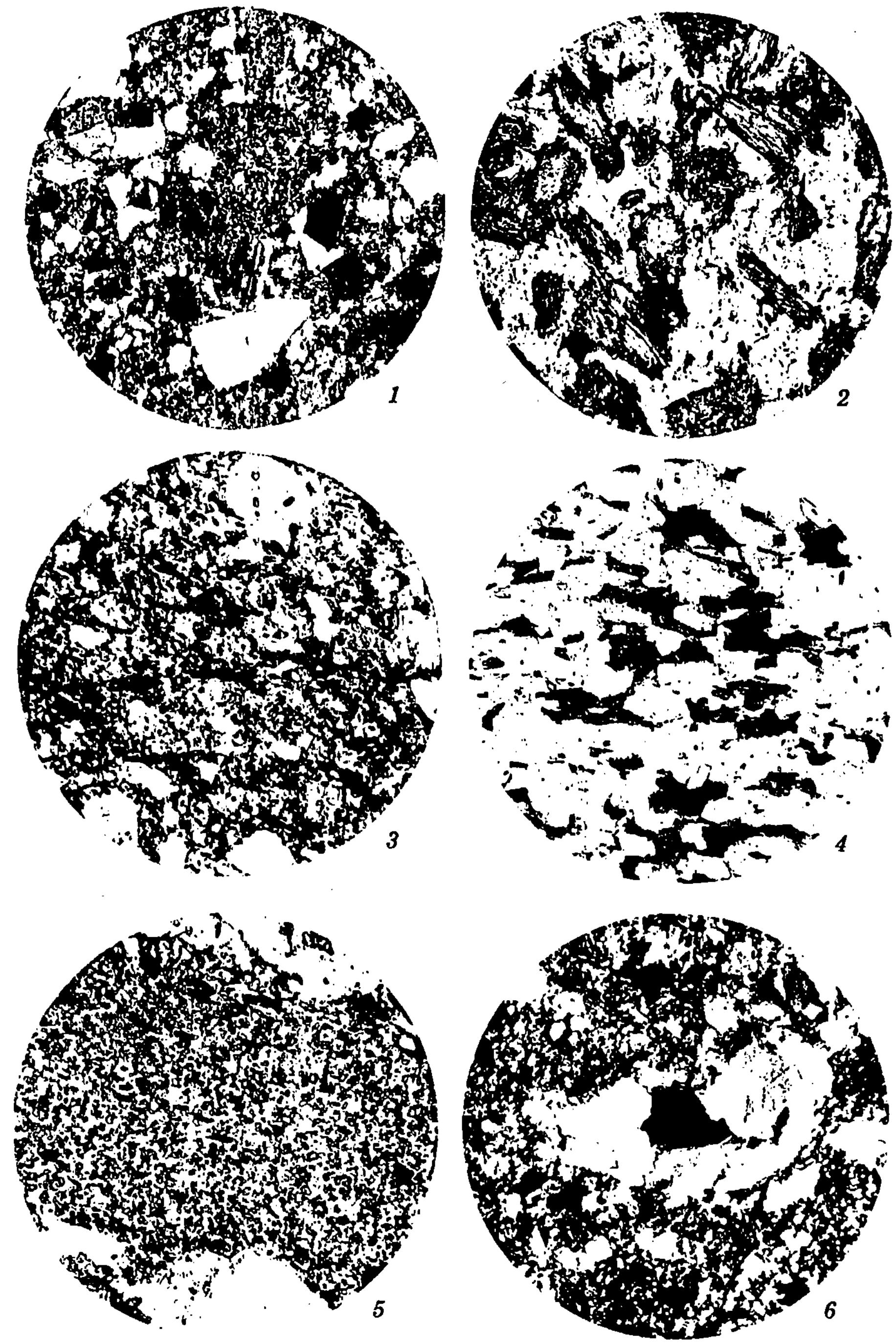
2. Amphibole hornfels, Mid Continent 1 Perry, SE¼ SE¼ SW¼ sec. 30, T. 1 S., R. 16 W., depth 1,720-1,740 feet. This rock represents a complete recrystallization of the rock shown in photograph 1 and is found only 220 feet below it. Pale-green, mildly pleochroic, tremolitic amphibole crystals are in a granoblastic mosaic of plagioclase and quartz. Biotite and sphene are also present. Thin section Ti-18-4. Ordinary light. Field diameter: 2.2 mm.

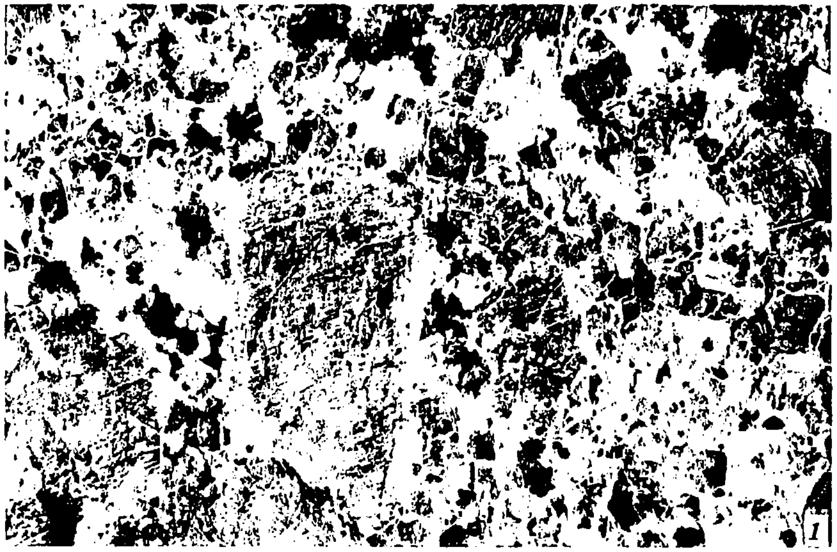
3. Meta-graywacke, Johnson and Russell 1 Holmes, SW¼ SW¼ SW¼ sec. 20, T. 2 S., R. 13 W., depth 2,260-2,270 feet. Microschistocity of biotite crystals in the recrystallized matrix is well defined. Quartz and feldspar fragments are essentially unaltered. Thin section Ct-2-1. Ordinary light. Field diameter: 0.76 mm.

4. Biotite schist, Mid Continent 1 Overton, NW¼ NE¼ NW¼ sec. 33, T. 1 S., R. 16 W., depth 1,670-1,690 feet. Lepidoblastic biotite crystals are in a quartz plagioclase mosaic, probably recrystallized from graywacke. Thin section Ti-35-1. Ordinary light. Field diameter: 0.77 mm.

5. Schist fragment in meta-graywacke, Continental 1 Smith, NW¼ SE¼ sec. 6, T. 2 S., R. 16 W., depth 3,325-3,341 feet. A fragment of schist 1.2 mm in total length is composed of epidote granules and lepidoblastic biotite in a granular quartz-feldspar mosaic. The fragment is extremely fine grained, most crystals being about ten microns in diameter. Thin section Ti-20-1. Ordinary light. Field diameter: 0.77 mm.

6. Composite quartz grain in meta-graywacke, Continental 1 Smith, NW¼ SE¼ sec. 6, T. 2 S., R. 16 W., depth 3,325-3,341 feet. The fragment is about 1.5 mm long and contains several crystallographic orientations of strained quartz. The grain is probably derived from a quartzite or coarse-sheared granite. Thin section Ti-20-1. Polarized light. Field diameter: 2.2 mm.





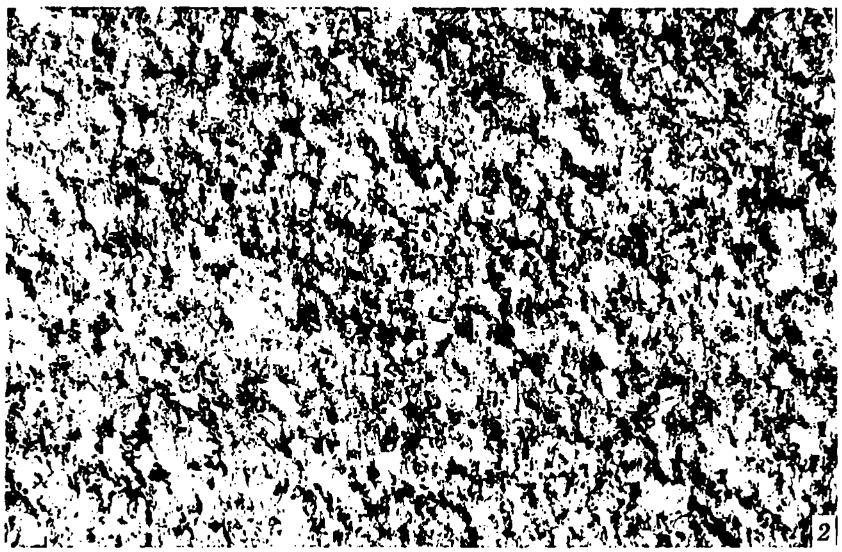


PLATE XV. POLISHED SPECIMENS OF GRANITES FROM THE EASTERN ARBUCKLE PROVINCE

1. Tishomingo granite, x1.7, Capitol Quarry, Ten Acre Rock, C NE¼ sec. 3, T. 3 S., R. 5 E. Large phenocryst of pink microcline (center) is surrounded by white plagioclase and clear quartz. The dark mineral is biotite, which occurs with sphene, epidote, and iron ore. Microcline is partly perthitic.

2. Strained granite, x1.3, Atlantic 1 Harvey, NW¼ SE¼ sec. 27, T. 3 N., R. 5 E., depth 4,800-4,807 feet. The granite is finer grained than the Tishomingo and shows cataclastic linears. White flecks are leucoxene. For photomicrograph see plate XVI-3.

Plate XVI. Photomicrographs of Granite, Mylonite, and Diorite from the Eastern Arbuckle Province

1. Granite, Phillips 1 Matoy, SW¼ NW¼ sec. 24, T. 5 S., R. 11 E., depth 11,510-11,520 feet. The rock is composed dominantly of quartz (white irregular grains), microcline (cross-hatched), and plagioclase (bottom), a small amount of biotite-chlorite aggregates and iron ore. The specimen is one of the finer grained granites of the province. Thin section Br-2-26. Polarized light. Field diameter: 1.7 mm.

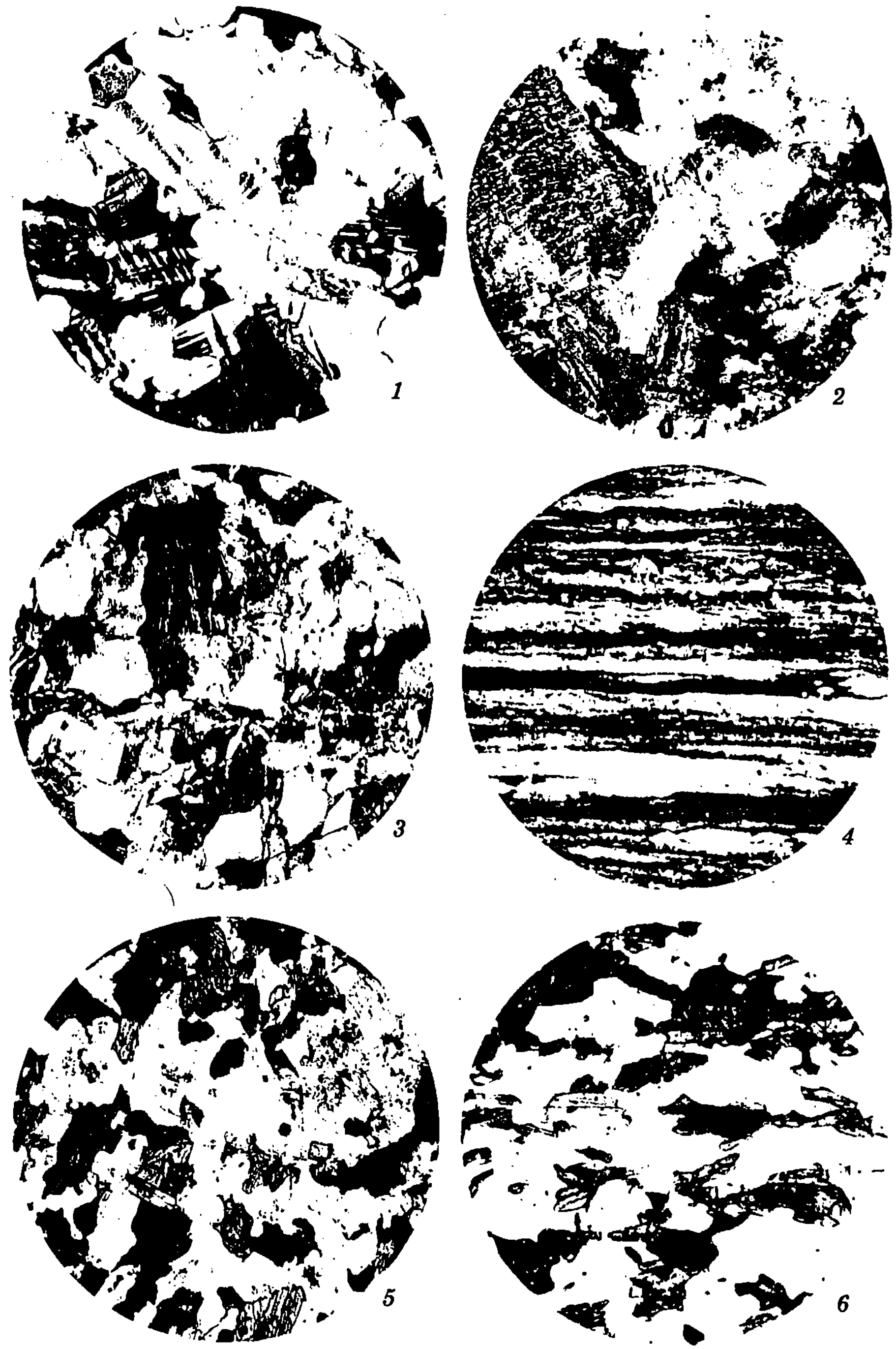
2. Granite, Sinclair 1 Peterson, NW¼ SW¼ NE¼ sec. 32, T. 6 S., R. 6 W., depth 4,663-4,666 feet. A coarse-grained granite containing microcline crystals exceeding 10 mm in length (upper left). Quartz crystals are highly strained and locally show mortar boundaries. Thin section Jf-15-4. Polarized light. Field diameter: 10.5 mm.

3. Strained granite, Atlantic 1 Harvey, NW¼ SE¼ sec. 27, T. 3 N., R. 5 E., depth 4,800-4,807 feet. Highly strained granite contains a linear of shearing horizontal through the photomicrograph. Microcline and plagioclase have bent twinning. Thin section (Pe-2-1) from core (pl. XV-2) showing crudely developed lineation. Polarized light. Field diameter: 3.7 mm.

4. Mylonite, California 1 Jones, NW¼ NW¼ NW¼ sec. 9, T. 7 S., R. 10 E., depth 4,790-4,800 feet. The mylonite contains small relict eyes of the parent granite. Banding results from layers alternately high in quartz and in clay-feldspar "paste." Thin section Br-8-2. Ordinary light. Field diameter: 2.1 mm.

5. Diorite, Phillips 1 Matoy, SW¼ NW¼ sec. 24, T. 5 S., R. 11 W., depth 835-845 feet. Well-crystallized hornblende and biotite are surrounded by clear to turbid andesine (An_{40}). Iron ore granules are scattered throughout the rock. Thin section Br-2-1. Ordinary light. Field diameter: 3.1 mm.

6. Schistose quartz diorite, Phillips 1 Matoy, SW¼ NW¼ sec. 24, T. 5 S., R. 11 W., depth 11,170-11,180 feet. Fine lepidoblastic (?) hornblende and biotite are associated with high-relief epidote in a mosaic of quartz and plagioclase containing small apatite crystals. Plagioclase is well twinned. Thin section Br-2-27. Ordinary light. Field diameter: 1.4 mm.



APPENDIX A

List of Wells Drilled into Basement Rocks in Southern Oklahoma

(Through August 31, 1962)

(List begins on page 182)

Sources of Information

All the wells listed in the table have been drilled in connection with the search for petroleum. Nearly all wells are direct exploration tests, but a few were drilled as stratigraphic tests or as salt-water-disposal wells. No water wells are included, as the few wells thus drilled into basement rocks are shallow and are situated near basement-rock outcrops where control information already is known.

The list has been compiled mainly by consulting all standard sources of information on petroleum exploratory drilling. The chief sources are the reports of the Oklahoma Corporation Commission (Oklahoma City), Research Oil Reports (Oklahoma City and Tulsa), D. B. Rhea Oil Reports (Oklahoma City), Herndon Map Service (Oklahoma City), the annual statistical volume of the Bulletin of the American Association of Petroleum Geologists (Tulsa), and the Yearbook of the National Oil Scouts and Landmen's Association (Austin, Texas). These reports are incomplete and partly inaccurate, however, and corrections resulting from examination of available samples and electric logs are given for specified wells listed in the table.

Valuable information also has been obtained from companies and individuals. Finally, we have made a few additions to the list after examining samples and discovering basement rocks in wells not previously listed.

Despite the exhaustive search, no claim can be made that the list is complete. Records of wells drilled before 1935 are unavailable or difficult to obtain and confirm, and even at the present time inadequate reports are made of shallow drilling by small independent operators. Kiowa and Greer Counties in particular have incomplete listings.

Arrangement of Wells in the Table

The wells are listed systematically in order to facilitate use of the table as a finding list. They are arranged first by townships, beginning with T. 10 N., and continuing progressively southward through T. 1 S. to T. 7 S. In each township they are further listed by ranges, beginning at the west boundary of Oklahoma and continuing to the east boundary of the investigated region. Thus all wells in T. 6 N. are arranged from R. 25 W. to R. 15 W., and those in T. 1 N. are arranged from R. 20 W. to R. 5 E. Several wells drilled within a single township are listed numerically from section 1 through section 36.

Oklahoma Geological Survey County Well Number

For ease in filing and handling, each well is assigned a county number as it is received by the Oklahoma Geological Survey. In the 17 counties of southern Oklahoma in which basement-rock wells have been drilled, the following abbreviations are used:

At.....Atoka	Cm...Comanche	Jk.....Jackson	Mr....Murray
Bk....Beckham	Ct.....Cotton	Jf.....Jefferson	Pe.....Pontotoc
Br.....Bryan	Gv....Garvin	Jn.....Johnston	St.....Stephens
Cr.....Carter	Gr.....Greer	Kw...Kiowa	Ti.....Tillman
			Wt....Washita

In Beckham County, for example, the first well received is designated Bk-1. Successive wells are listed in ascending numerical order to the highest number for that county.

The numerical sequence for some counties is incomplete because (a) wells are occasionally duplicated by the drilling of a twin well, or by the listing of a single well by the names of different partnership operators, and (b) most commonly, a well is reported as a basement-rock test whereas examination of the bottom-hole samples shows them to be granite wash, conglomerate, or indurated Paleozoic sandstone. Wells of this type, although listed in the Geological Survey file, are generally omitted from the table.

Depth to Top of Basement Rocks

An attempt was made to obtain samples and electric logs from all reported basement-rock wells in southern Oklahoma. Of the 428 wells listed, we were able to obtain samples from 178 wells, many of them with electric logs. The most reliable information about the top of the basement rocks is provided by these wells, and the tops given for them represent the best opinion of the Oklahoma Geological Survey. The depth and corresponding elevation do not necessarily agree, however, with the top picked in the same well by other geologists.

Electric logs were available for 20 additional wells from which samples were not obtained but in which the electric-log character was sufficiently distinct to permit the determination of a basement-rock top.

Basement-rock wells reported from various sources but unconfirmed by examination of samples or electric logs by the Oklahoma Geological Survey are listed in the table.

The method of listing is as follows:

S sample examination by Oklahoma Geological Survey
E electric-log examination by Oklahoma Geological Survey
R report not confirmed by Oklahoma Geological Survey

Rock Group

Six basement-rock groups have been established in southern Oklahoma. One or more of these rock groups identified in a well by petrographic examination of samples is listed in the table according to the following abbreviations.

WG......Wichita Granite Group	RMG...Raggedy Mountain Gabbro Group
CR........Carlton Rhyolite Group	TM......Tillman Metasedimentary Group
NMBS. Navajoe Mountain Basalt-Spilite Group	EAP...Eastern Arbuckle Province

Petrographic Description

Descriptions of cuttings and cores from petrographic examination of thin sections are given in appendix B. They are cross-listed in the last column of the table by the citation of the page or pages on which the thin sections are described.

OGS County Number	Operator and Lease	Location	Date Drilled	Total Depth (feet)	Surface Elevation (feet)	Age of Overlying Strata	BASEMENT ROCKS: Depth to Top (feet)*	Thickness Penetrated (feet)	Elevation of top (feet)	Rock Group*	Petrographic Description (page)
Bk-1	Pure Oil No.1 Taute	NW SE 34-10N-25W	1948	8117	1947	Permian	7919 S	198	- 5972	WG	211
Bk-40	Wood Petr.& Royalty (Star Oil) No.1 Blair	C NW SE 32-9N-26W	1936	2989	2087	Permian	2920 S	69	- 833	WG	217
Bk-50	Domac Oil No.1 Sanders	NE SE 35-9N-26W	1959	7752	2047	Pennsylvanian	7726 S	28	- 5679	WG	219
Bk-52	Major Oil Dev.& Pan Am.Petr. No.1 Sanders	NE SE 35-9N-26W	Rework of Bk-50, q.v.								
Bk-2	Tidewater-Skelly No.1 Baldwin	SE NE NE 10-9N-25W	1945	7559	1995	Permian	7220 E & S	339	- 5225	WG CR	211
Bk-56	T. K.Hendrick et al. No.1 Hatcher	SW SE NW 10-9N-25W	1961	7248	1999	Permian	(R 7200)	48	- 5201		
Bk-3	United Carbon & Skelly Oil No.1 Wooten Unit	SW NE NW 11-9N-25W	1952	7780	1986	Permian	7695 E & S	85	- 5709	WG	212
Bk-4	A. R. Jordan No.1 Caudill Estate	SE SE SE 27-9N-25W	1949	6371	1996	Permian	(R 4660)	1711	- 2664	WG	212
Bk-5	V.J.Devine et al. No.1 Watson	NE NE 34-9N-25W	1950	3929	2003	Permian	3325 S	604	- 1322	WG	212
Bk-12	Shell Oil No.1 Randle	C SE SW 15-9N-23W	1957	4308	1871	Permian	4185 S	123	- 2314	WG	214
Bk-13	Phillips Petr. No.1 Martin	C NW NE 27-9N-23W	1934	6944	1884	Permian	(R 3950±)	2986	- 2066	WG	215
Bk-14	Rogers-Fain No.1 Windle	SE NW SE 31-9N-23W	1953	6502	1912	Permian	6426 S	76	- 4514	WG	215
Bk-18	Gulf Oil No.1 Joe Back	NW SE 34-9N-22W	1958	8028	1827	Permian	6995 E & S	1033	- 5168	WG	215
Bk-30	Carter Oil No. 1 State Taylor	C SW SW 31-9N-21W	1951	10699	1861	Permian	6648 E & S	764 faulted	- 4787	WG	217
Bk-57	Barnes No. 1 Gamble	C NW NE 7-8N-26W	1962	3400	2108	Permian	2525	875	- 412	RMG	219
Bk-55	Buffalo Oil (Van Hooser) No. 1 Graves	SW NE NW 8-8N-26W	1924	3519	2120±	Permian	probably near 2800	700±	- 680±		
Bk-54	Major Oil No. 1 Phillips	SE NE 11-8N-26W	1960	4400	2083	Permian	4335 S	65	- 2252	WG	219

OGS County Number	Operator and Lease	Location	Date Drilled	Total Depth (feet)	Surface Elevation (feet)	Age of Overlying Strata	Depth to Top (feet)*	Thickness Penetrated (feet)	Elevation of top (feet)	Rock Group*	Petrographic Description (page)
Bk-41	Pierce Oil No. 1 Prath	SE SE NE 21-8N-26W	1920	2461	2071	Permian	2415 S	46	- 344	WG	217
Bk-42	Carter Oil & Bud Lewis No. 1 Bingham	C NE NE 31-8N-26W	1937	2214	1919	Permian	2152 S	62	- 233	RMG	217
Bk-43	Jo Gail No. 1 Gilliland	NE NE NE 33-8N-26W	1936	2538	2040±	Permian	2294 S	244	- 254	RMG & WG	217
Bk-9	Magnolia Petr. No. 1 Roberts	SE SE NE 4-8N-25W	1926	3700	1974	Permian	(R 3643)	57	- 1669		
Bk-47	Gradan No. 1 Toon	NW NW NW 11-8N-25W	1952	2333	2018	Permian	(R 2332)	1	- 314		
Bk-24	Tierra Blanca No. 1 McGee	SW NE SE 25-8N-25W	1954	1450	1698	Permian	Not a confirmed basement test				
Bk-10	Stephens Petr. No. 1 Pennington	NW NW NW 27-8N-25W	1946	2402	2090	Permian	2210± S	192	- 120	RMG	214
Bk-11	W. Braden No. 1 Rodgers	SW SW SW 30-8N-25W	1930	2310	2078	Permian	(R 2309)	1	- 232		
Bk-15	Skelly Oil No. 1 Batchlear	NW NW SE 24-8N-23W	1923	3790	1738	Permian	(R 3604)	186	- 1866		
Bk-16	Robert Brown No. 1 Lawrence	NW NW 36-8N-23W	1957	1785	1757	Permian	1758 E	27	+ 1		
Bk-17	The Reinhart & Donovan No. 1 Tatyrek	SE SE SE 36-8N-23W	1953	4004	1714	Permian	1650 E	2354	+ 64		
Bk-19	Big Chief Drlg. No. 1 Weaver	SW SW NE 8-8N-22W	1954	2208	1791	Permian	1985 S	223	- 194	WG	215
Bk-20	Gulf Oil No. 1 Day	SE NE SE 12-8N-22W	1945	3002	1765	Permian	1959 E & S	1043	- 194	WG	216
Bk-49	Cecil Simms No. 1 Denby	NE NE SW 18-8N-22W	1959	1500	1580±	Permian	(R 1481)	19	+ 99±		
Bk-48	Darrell C. Williams No. 2 Chandler	NE NE NE 22-8N-22W	1958	1566	1688	Permian	(R 1565)	1	+ 123		
Bk-21	Silberman No. 1 Van Vacter	NW SE SE 24-8N-22W	1954	1586	1671	Permian	1535 E & S	51	+ 136	WG	216
Bk-22	Abbe-Kildow No. 1 Van Vacter	SW SE NE 25-8N-22W	1950	985	1691	Permian	(R 926?)	59	+ 765		

*See explanation, pages 180-181.

OGS County Number	Operator and Lease	Location	Date Drilled	Total Depth (feet)	Surface Elevation (feet)	Age of Overlying Strata	BASEMENT ROCKS: Depth to Top (feet)*	Thickness Penetrated (feet)	Elevation of Top (feet)	Rock Group*	Petrographic Description (page)
Bk-23	W. R. Duke No. 1 McGee	NE NE SE 25-8N-22W	1927	1955	1720±	Permian	(R 1500)	455	+ 220		
Bk-25	D. C. Williams No. 1 McGee	SE NW SE 25-8N-22W	1958	1250	1710	Permian	(R 1248)	2	+ 462		
Bk-26	Mid American Drlg. No. 1 Briscoe	SW SW SW 28-8N-22W	1938	2764	1774	Permian	(R 1745)	1019	+ 29	RMG	216
Bk-27	Ware No. 1 Tolman	NE NW NE 36-8N-22W	1955	1121	1728	Permian	(R 1096)	25	+ 632		
Bk-28	Butcher & Delta Petr. No. 1 Wall	SE SE NE 36-8N-22W	1957	1099	1735	Permian	(R 1097)	2	+ 638		
Bk-29	Ernest May No. 1 Jackson	SE SW SE 36-8N-22W	1956	1370	1795±	Permian	(R 1350)	20	+ 445		
Bk-31	Burt Oil No. 1 Van Vacter	NW NW NW 29-8N-21W	1954	1940	1679	Permian	(R 1355)	585	+ 324		
Bk-32	Amarillo Oil No. 1 Bohannon	SE NW SE 29-8N-21W	1954	1485	1671	Permian	(R 1420)	65	+ 251		
Bk-34	Burt Oil No. 1 Wall	NW NW NE 31-8N-21W	1954	3001	1703	Permian	(R 1327)	1674	+ 376		
Bk-35	Raymond Sandler No. 8 Trissell	SW NE SE 31-8N-21W	1957	1075	1703	Permian	(R 1073)	2	+ 630		
Bk-36	Shadid No. 3 Trissell	NE SE SW 31-8N-21W	1957	992	1720	Permian	(R 989)	3	+ 731		
Bk-37	J. A. Hedgecoke No.2 Trissell	NW SE SW 31-8N-21W	1957	994	1719	Permian	(R 993)	1	+ 726		
Bk-45	Barry Goldberg No. 9 Trissell	SE SE SE 31-8N-21W	1958	955	1707	Permian	(R 954)	1	+ 753		
Bk-51	Barnes, Sandler & Goldberg No. 12 Trissell	SW SW NE 31-8N-21W	1960	736	1699	Permian	(R 735)	1	+ 964		
Bk-38	E. L. Boyd No. 1 Bohannon	NE SW 32-8N-21W	1957	1430	1641	Permian	(R 1370)	60	+ 271		
Bk-39	Day Oil No. 1 Ault	C NW NW 33-8N-21W	1929	1508	1674	Permian	(R 1500)	8	+ 174		

OGS County Number	Operator and Lease	Location	Date Drilled	Total Depth (feet)	Surface Elevation (feet)	Age of Overlying Strata	Depth to Top (feet)*	Thickness Penetrated (feet)	Elevation of Top (feet)	Rock Group*	Petrographic Description (page)
Bk-53	Ramsey Garrett No. 1	NW SE SE 34-8N-21W	1955	1666	1631	Permian	1655	11	- 34	RMG	219
Wt-3	Champlin Oil & Ref. No. 1 Hieber	SW SW NW 30-8N-20W	1952	10036	1748	Permian	1970 S & E	8066	- 222	RMG 1970 to 10015 WG 10019 to 10036	295
Wt-1	Oklahoma Midwest Oil No. 1 Dock	SW SW SW 21-8N-18W	1934	2860	1672	Permian	2745 S	+ 15	- 1073	CR	292
Wt-2	Shell Oil No. 1 Galloway	SE SE SE 21-8N-18W	1954	6499	1675	Permian	2132 S & E	4367	- 457	CR	292
Wt-4	Sunray & Aubyme Oil & Gas No. 1 Rice	SE SE SE 33-8N-18W	1924	2185	1646	Permian	1975 S	210	- 329	WG	298
Bk-44	Kroy American Oils No. 1 Francis	SW SW NE 7-7N-26W	1957	3429	1987	Permian	3130 E & S	299	- 1143	RMG	218
Bk-6	Phillips Petr. No. 1 Nance	SE SE NW 8-7N-25W	1944	2300	1990	Permian	2175 S	125	- 185	WG RMG	213
Bk-7	Lewis Drlg. No. 1 Garrett	NE NE NE 11-7N-25W	1937	2266	1975	Permian	2195 S	71	- 220	WG	213
Bk-8	Taylor No. 1 Fee	NW NW SE 27-7N-25W	1921	2819	2060	Permian	2765 S	54	- 705	CR	214
Gr-68	The Shamrock Oil & Gas No. 1B Rogers	NE NE SW 24-7N-24W	1959	2100	1896	Permian	(R 2090)	10	- 194		
Gr-46	Columbian Fuel No. 1 Harris	NW SE NW 34-7N-24W	1958	1618	1774	Permian	1591 S	27	+ 183	CR	248
Gr-1	J. Henderson No. 1 Dugger	SW SW NE 7-7N-23W	1956	1704	1712	Permian	1675 S	29	+ 37	WG	245
Gr-67	The Shamrock Oil & Gas No. 1 Covington	W½ SE 30-7N-23W	1959	1965	1860	Permian	(R 1955)	10	- 95		
Gr-2	Neal et al. No. 1 Dooley	NW NW NW 1-7N-22W	1931	1575	1756	Permian	1545 S	30	+ 211	WG	245
Gr-3	Greater Okla. Oil No. 1 Bowman	NW NW NE 9-7N-22W	1918	1810	1756±	Permian	(R 1640)	170	+ 116		
Gr-4	Bolin Oil No. 1 Magnolia	SW SE 15-7N-22W	1956	1750	1775	Permian	1629 S	121	+ 146	RMG	245
Gr-69	Childress Drlg. No. 1 Roberts	NE SE NW 26-7N-22W	1955	1615	1740	Permian	(R 1614)	1	+ 126		

*See explanation, pages 180-181.

KGS County Number	Operator and Lease	Location	Date Drilled	Total Depth (feet)	Surface Elevation (feet)	Age of Overlying Strata	BASEMENT ROCKS Depth to Top (feet)*	Thickness Penetrated (feet)	Elevation of Top (feet)	Rock Group*	Petrographic Description (page)
Gr-64	Arwood H. Stowe No. 1 McDaniels	SW SE SE 32-7N-22W	1960	1422	1700	Permian	(R 1419)	3	+ 281		
Gr-5	D. W. Beck No. 1 Trissell	NW NW NW 5-7N-21W	1956	1155	1681	Permian	(R 1060)	95	+ 621		
Gr-6	Bolin Oil No. 1 Ledgerwood	SE NW SW 5-7N-21W	1956	1046	1681±	Permian	(R 1042)	4	+ 639		
Gr-7	Bolin Oil No. 9 Trissell	NE NW NE 6-7N-21W	1957	950	1713	Permian	(R 949)	1	+ 764		
Gr-8	F. A. Gillespie No. 1 Stooksberry	NE NW SE 9-7N-21W	1947	1549	1696	Permian	1504 E	45	+ 192		
Gr-9	Hazeloff & Kunkle Drlg. No. 1 Garrett Estate	NE SW NW 10-7N-21W	1956	1453	1665	Permian	(R 1446)	7	+ 219		
Gr-10	Stephens Petr. No. 1 School Land	NW NW SE 16-7N-21W	1945	1452	1707	Permian	1388 E & S	64	+ 319	RMG	245
Gr-11	Russell Cobb, Jr. No. 1 Blain	NE SW SW 23-7N-21W	1957	1257	1648	Permian	(R 1250)	7	+ 398		
Gr-12	McCluskey & Brown No. 1 Curtiss	NW NW SE 27-7N-21W	1954			Not a basement test (from sample examination)					
Gr-41	Hazelton No. 1 Barber	NE SE SE 32-7N-21W	1954	690	1653	Probably not a basement test					
Gr-42	E. L. Pinkston No. 1 Hunter	SE NE SW 35-7N-21W	1950	1240	1647	Permian	(R 1239)	1	+ 408		
Gr-70	Hedgecoke Properties No. 1 Nelson	SW SW SE 35-7N-21W	1955	623	1672	Permian	(R 622)	1	+ 1050		
Kw-73	E. L. Martin No. 1 Fee	SW NW NW 5-7N-20W	--	1783	1680	Permian	1662 E	121	+ 18		
Kw-1	Dore & Rolls No. 1 Mitchell	SW NW SW 9-7N-20W	1957	1600	1643	Permian	(R 1529)	71	+ 114		
Kw-2	Naylor No. 1 Allen	SE SE NE 9-7N-20W	1955	1650	1663	Permian	(R 1630)	20	+ 33		
Kw-56	R. S. Brown No. 1 Randall	NW NW NW 17-7N-20W	1958	1591	1504	Permian	(R 1584)	7	- 80		

KGS County Number	Operator and Lease	Location	Date Drilled	Total Depth (feet)	Surface Elevation (feet)	Age of Overlying Strata	Depth to Top (feet)*	Thickness Penetrated (feet)	Elevation of Top (feet)	Rock Group*	Petrographic Description (page)
Kw-3	Tidewater-Skelly Oil No. 1 Smith	NW SW SE 23-7N-20W	1942	1800	1714	Permian	(R 1630)	170	+ 84	RMG	265
Kw-4	Langford, P. P. No. 1 Burnett	NE SE NE 30-7N-20W	1948	1065	1614	Permian	(R 1063)	2	+ 551		
Kw-5	Son Pickard Oil No. 1 Harper	NW NW 31-7N-20W	1921	1100	1638	Permian	(R 1095)	5	+ 543		
Kw-6	Hinerman & McWhirtle No. 1 Vandernack	NE NE NW 3-7N-19W	1941	2351	1625	Permian	(R 2350)	1	- 725		
Kw-7	Jack Hinerman et al. No. 1 Wax	NW NW NE 3-7N-19W	1943	2410	1584	Permian	(R 2410) 2409	1	- 826 - 825		
Kw-74	Anderson-Pritchard Oil No. 1 Cribbs	SE SE NE 28-7N-19W	1938	1825	1563	Permian	1685 S	140	- 122	WG	269
Kw-8	Warlick No. 1 Wayne	NE SE SE 2-7N-18W	1942	1622	1599	Permian	1614 S	8	- 15	WG	265
Kw-9	L. D. Cain No. 1 Braun	NW NW SW 2-7N-18W	1955	1660	1592	Permian	(R 1640)	20	- 48		
Kw-10	Wegener Drlg. No. 1 Bretch	NW NW SW 5-7N-18W	1955	1796	1640	Permian	1776 S & E	20	- 136	WG	265
Kw-68	Christain No. 1 James	NE NE SE 8-7N-18W	1930	1852	1619	Not a basement test (from sample examination)					
Kw-11	Lewis & Meyer (Teci Prod.) No. 1 Fowler	SE SE NW 10-7N-18W	1940	1680	1582	Permian	1573 S	107	+ 9	WG?	265
Kw-12	Spadling & Ballew No. 1 State	SE SW SW 13-7N-18W	1948	1299	1648	Permian	1253 E	46	+ 395		
Kw-13	Lewis & Meyers No. 1 Ford	NE NE SE 14-7N-18W	1939	1786	1647	Permian	1420 S	366	+ 227	WG	266
Kw-14	Royal Petr. No. 1 Reed	NE NE SW 19-7N-18W	1947	1426	1591	Permian	(R 1420)	6	+ 171		
Kw-15	J. H. Whitling et al. No. 1 Patchin	NE NW NW 28-7N-18W	1939	2342	1534	Permian	1420 S	922	+ 114	WG	266
Kw-16	Childress Drlg. No. 1 Hobbs	NW NE NE 34-7N-18W	1953	1500	1576	Permian	1420 S	80	+ 156		
Kw-17	Wilcox Oil & Gas No. 1 Grieser	SW SW NE 35-7N-18W	1942	1564	1589	Permian	1458 S	6	+ 131	RMG	266

*See explanation, pages 180-181

OGS County Number	Operator and Lease	Location	Date Finished	Total Depth (feet)	Surface Elevation (feet)	Age of Overlying Strata	Basement Rocks: Depth to Top (feet)*	Basement Rocks: Thickness Penetrated (feet)	Basement Rocks: Elevation of Top (feet)	Basement Rocks: Rock Group*	Basement Rocks: Petrographic Description (page)
Kw-18	A. A. Potter No. 1 School Land	NE NW SE 36-7N-18W	1952	1316	1602	Permian	(R 1299)	17	+ 303		
Kw-19	Artie Baker No. 1 Copeley	NW NE SE 30-7N-17W	1941	1289	1599	Permian	1268 S	21	+ 331	WG & NMBS?	266
Kw-75	Austin I. Lewis No. 1 Coakley	SE NE SE 30-7N-17W	1945	1282	1570	Permian	1250 S	32	+ 320	WG & NMBS?	269
Kw-66	A. E. Pearson No. 1 Folks	SE SW NW 32-7N-17W	1956	1832	1537	Permian	(R 1640)	192	- 103	WG & NMBS?	269
Kw-20	Beelér & Cline No. E Kirk	NW NW NW 35-7N-15W		858	1381	Permian	(R 450)	408	+ 931		
Kw-79	Van Kirk No. 1 Malernee	NW NW NW 35-7N-15W		850	1381	Permian	516 S	334	+ 865	CR	270
Kw-84	Klein No. 1 Van Kirk	NE NE SW 35-7N-15W	1939	607	1403	Permian	515 S	92	+ 888	CR	271
Gr-62	El Paso Natural Gas No. 1 Birdwell	SW SE SW 10-6N-25W	1960	1950	1847	Company reports Permian rocks at total depth.					
Gr-57	R. M. Laurence No. 1 Aaron	SE SE SE 25-6N-25W	1959	2962	1666	Permian	2942 S	20	- 1276	CR	250
Gr-56	The Shamrock Oil & Gas No. 1 Rusk	SW SW SW 1-6N-24W	1959	1560	1692	Permian	1535 S	25	+ 157	CR	250
Gr-13	Gragg Oil No. 1 Heatley	SW NW NW 3-6N-24W	1955	1456	1743	Permian	1443 S	13	+ 300	CR	246
Gr-60	The Shamrock Oil & Gas No. 1 Boyd	SW SW 10-6N-24W	1959	1448	1708	Permian	1278 S	170	+ 430	CR	251
Gr-47	Columbian Fuel No. 1 Richards	SW NE SW 11-6N-24W	1958	1287	1721	Permian	1227 S	60	+ 494	CR	248
Gr-59	The Shamrock Oil & Gas No. 2 McDonald	NE SW SW 14-6N-24W	1959	1466	1691	Permian	less than 1421	45+		CR	251
Gr-14	Decker, Read & I.T.I.O. No. 1 Foster	C SW NE 17-6N-24W	1930	2481	1725	Permian	less than 2350	131+		CR	246
Gr-63	El Paso Natural Gas No. 1 Heatley	NE NE 17-6N-24W	1960	1591	1746	Permian	(R 1580)	11	+ 166		

OGS County Number	Operator and Lease	Location	Date Finished	Total Depth (feet)	Surface Elevation (feet)	Age of Overlying Strata	Basement Rocks: Depth to Top (feet)*	Basement Rocks: Thickness Penetrated (feet)	Basement Rocks: Elevation of Top (feet)	Basement Rocks: Rock Group*	Basement Rocks: Petrographic Description (page)
Gr-16	Gragg Oil No. 1 Halford	SE SE SE 23-6N-24W	1954	1550	1687	Permian	1395 S & E	155	+ 292	CR	246
Gr-58	The Shamrock Oil & Gas No. 1-A Frost	SE NW 24-6N-24W	1959	1462	1630	Permian	1415 S	47	+ 215	CR	251
Gr-66	The Shamrock Oil & Gas No. 1 Travis	C NW 9-6N-23W	1960	1398	1678	Permian	(R 1388)	10	+ 290		
Gr-55	Columbian Fuel No. 1 Taylor	NW SE SE 22-6N-23W	1959	825	1622	Permian	824 S	1	+ 798	RMG	250
Gr-61	Arwood H. Stowe No. 1 Moore	NW SE 9-6N-22W	1960	1339	1684	Permian	(R 1336)	3	+ 348		
Gr-50	Columbian Fuel No. 6 Strat. test	NW NW NE 22-6N-22W	1958	1262	1656	Permian	1250 S	12	+ 406	RMG	249
Gr-53	Columbian Fuel No. 1 Taylor	NE SE SW 23-6N-22W	1959	834	1624	Permian	812 S	22	+ 812	WG	249
Gr-44	Columbian Fuel No. 2 Johnson	SW SW NE 26-6N-22W	1958	683	1616	Permian	676 S	7	+ 940	WG	248
Gr-48	Columbian Fuel No. 1 Strat. test	SE SE NE 26-6N-22W	1958	890	1614	Permian	875 S	15	+ 739	WG	248
Gr-54	Columbian Fuel No. 1 Schumate	SW NE NW 26-6N-22W	1959	549	1612	Permian	548 S	1	+ 1064	WG	250
Gr-49	Columbian Fuel No. 4 Strat. test	NE SE NE 27-6N-22W	1959	740	1623	Permian	736 S	4	+ 887	WG	249
Gr-51	Columbian Fuel No. 7 Strat. test	SE SE NE 28-6N-22W	1958	1321	1615	Permian	1313 S	8	+ 302	WG	249
Gr-52	Columbian Fuel No. 2 Strat. test	SW SW SE 35-6N-22W	1958	1216	1610	Permian	1212 S	4	+ 398	WG	249
Gr-17	Heiskell No. 1 Hoover	NW NW 1-6N-21W	1955	802	1662	Permian	(R 620)	182	+ 1042		
Gr-18	H. B. & C. Oil No. 1 Sewell	SW SW SW 2-6N-21W	1954	681	1654±	Permian	(R 680)	1	+ 974		
Gr-19	E. M. Thomasson No. 3 Craig	SW NE SE 3-6N-21W	1946	783	1665	Permian	(R 565?)	218	+ 1100		
Gr-20	Allaun et al. No. 3 Hogg	NW NW SW 3-6N-21W	1955	537	1663	Permian	(R 532)	5	+ 1131		

*See explanation, pages 180-181.

OGS County Number	Operator and Lease	Location	Date Drilled	Total Depth (feet)	Surface Elevation (feet)	Age of Overlying Strata	BASEMENT ROCKS Depth to Top (feet)*	Thickness Penetrated (feet)	Elevation of Top (feet)	Rock Group*	Petrographic Description (page)
Gr-21	S & B Oil No. 3 Murray	SE NE NE 4-6N-21W	1956	650	1663±	Permian	(R 610)	40	+ 1053		
Gr-22	Gilliam et al. No. 2 Gaither	NW NW SE 5-6N-21W	1955	525	1667±	Permian	(R 524)	1	+ 1143		
Gr-39	Woodruff-Hunter & Everitt No. 1 Hahan	NE SW NW 7-6N-21W	1946	1309	1705	Permian	(R 1308)	1	+ 397		
Gr-23	Porter et al. No. 1 Dillahunty	NW NW NE 8-6N-21W	1955	297	1675	Permian	(R 290)	7	+ 1385		
Gr-24	Fredrick Oil No. 3 Armstrong	SW NW NE 10-6N-21W	1918	168	1678±	Permian	(R 165)	3	+ 1513		
Gr-40	E. M. Thompson No. 3 Armstrong Heirs	NW NW NE 10-6N-21W	1944	328	1702	Permian	(R 327)	1	+ 1375		
Gr-25	M & M Oil (McLennon) No. 1 Nelson	SE SE SW 30-6N-21W	1944	1284	1598	Permian	(R 785)	499	+ 813		
Gr-26	Briggs No. 1 Burress	NE SW 5-6N-20W	1919	1017	1600±	Permian	(R 950)	67	+ 650		
Kw-107	The Reinhart & Donovan No. 1 McConnell	SW SW SE 13-6N-20W	1960	1065	1580±	Permian	(R 1002)	63	+ 578		
Kw-21	D. T. Potts No. 1 Bell	NW NW NE 22-6N-20W	1947	689	1613	Permian	(R 683)	6	+ 930		
Kw-69	Reynolds Dev. No. 1 McDonald	SE SW SE 22-6N-20W	1949	2065	1616	Permian	(R 790)	1275	+ 826		
Kw-57	R. S. Brown No. 1 Bennick	SW SW SW 24-6N-20W	1958	800	1569	Permian	(R 796)	4	+ 773		
Kw-113	The Reinhart & Donovan No. 1 Harris	NE NW SW 27-6N-20W	1960	1943	1620±	Permian	(R 1841)	102	- 221		
Kw-22	Kiowa Petr. No. 1 School Land	NW NW NE 33-6N-20W		960	1559	Permian	(R 920)	40	+ 639		
Kw-23	Alert Petr. No. 1 Patterson	SE SE SW 2-6N-19W	1922	1518	1575	Permian	(R 1404)	114	+ 171		
Kw-86	W. C. Cummings No. 1 Straub	NE NE SE 3-6N-19W	1959	1481	1580±	Permian	(R 1480)	1	+ 100		
Kw-78	H. J. Hartwell No. 1 Reed	SW SE NE 12-6N-19W	1947	1364	1552	Permian	(R 1363)	1	+ 189		
Kw-63	Raymond Greer No. 1 Winfrey	NE NE NW 24-6N-19W	1953	1167	1559	Permian	(R 1160)	7	+ 399		
Kw-64	T. Y. Gorman et al. No. 1 Shelburne	SE SE SW 28-6N-19W	1958	575	1542	Permian	(R 574)	- 1	+ 968		
Kw-72	Thomason No. 3 Baker	NE NW NW 7-6N-18W	1942	1199	1539	Permian	(R 1198)	1	+ 341		
Kw-24	An-Son Petr. No. 1 Tomahty	SE SW NW 8-6N-18W	1950	1182	1504	Permian	(R 1181)	- 1	+ 323		
Kw-88	Hughes (Reinhart & Donovan) No. 1 Foltz	SE SE SE 10-6N-18W	1937	1199	1580±	Permian	1098 S	101	+ 482	RMG	272
Kw-25	Stauffer Petr. No. 1 Mayo	NE NE NW 13-6N-18W	1942	1704	1533	Permian	1055 S	649	+ 478	RMG & WG	267
Kw-67	Reinhart & Donovan No. 1 Dugger	NE SW SW 14-6N-18W	1941	2400	1520	Permian	(R 1150)	1250	+ 370		
Kw-110	Earl Sossaman No. 1 Mothersead	NE NE NE 24-6N-18W	1958	1815	1550±	Permian	(R 1620)	195	- 70		
Kw-50	Jack Villines No. 1 Funkhouser	NE NE SE 31-6N-18W	1958	786	1492	Permian	(R 707)	79	+ 785		
Kw-26	Copeland No. 1 Braun	SW SW 36-6N-18W	1944	721	1528	Permian	(R 720)	1	+ 808		
Kw-70	Walters (DeBolt) No. 1 McCurdy	NW SE SE 7-6N-17W	1947	975	1496	Permian	939 S	36	+ 557	RMG	269
Kw-51	Dublin-Kiel & Null No. 1 Stone	NE NE SE 15-6N-17W	1958	880	1483	Permian	(R 790)	90	+ 693		
Kw-71	W. F. Collins No. 1 Barnes	SE SW NW 21-6N-17W	1954	550	1508	Permian	(R 548)	2	+ 960		
Kw-91	Mercer-Huffine & Krohn No. 1 Kutz	SE SW NW 21-6N-17W	1950	1621	1510	Permian	886 E	735	+ 624		
Kw-27	Harber & Polk No. 1 Parr	SW SW SW 22-6N-17W	1957	1362?	1510	Permian	about 780	582±	+ 730	RMG	268
Kw-54	Barton & Polk Drlg. No. 1 Parr	SW SW SW 22-6N-17W	1958	1322	1513	Permian	786 E	536	+ 727	RMG	269

*See explanation, pages 180-181

OGS County Number	Operator and Lease	Location	Date Drilled	Total Depth (feet)	Surface Elevation (feet)	Age of Overlying Strata	BASEMENT ROCKS: Depth to Top (feet)*	Thickness Penetrated (feet)	Elevation of top (feet)	Rock Group*	Petrographic Description on page
Kw-87	Cabot Carbon No. 1 Parr	NE NE NE 22-6N-17W	1959	854	1475	Permian	(R 852)	2	+ 623		
Kw-52	Marshall & Wiskirchen Drlg. No. 1 Kerr	SW SE SE 26-6N-17W	1958	560	1456	Permian	(R 559)	1	+ 897		
Kw-53	Marshall & Wiskirchen Drlg. No. 3 Kerr	NE NE SE 26-6N-17W	1958	582	1456	Permian	(R 580)	2	- 876		
Kw-81	Radar Oil No. 29-1 Gerber	NE NE SE 29-6N-17W	1958	1400	1555	Permian	892 E	508	+ 663	RMG	271
Kw-90	R. E. Maxey No. 1 Milligan	NE NE SW 29-6N-17W	1958	1393	1552	Permian	916 E	477	+ 636		
Kw-106	Turner (P. E. Berry) No. 1 Wobrock	NE NE SE 30-6N-17W	1960	837	1540	Permian	(R 599)	238	+ 941		
Kw-28	Caudill-Bed Rock Partnership No. 1 Koeppe	NW SE 31-6N-17W	1921	730	1539	Permian	(R 718)	12	- 821		
Kw-29	Frank Walters No. 1 Minton	SE SE SW 3-6N-16W	1957	702	1413±	Basement erroneously reported at 698 Basement expected at 8500					
Kw-77	F. W. Burger No. 1 Dudgeon	NE NE SW 31-6N-16W	1957	550	1431	Permian	(R 549)	1	+ 882		
Kw-30	Amphlett No. 1 Parr	NE SW NW 32-6N-16W	1929	465	1422	Permian	(R 450)	15	+ 972		
Kw-94	J. B. Bourland No. 1 Burton-A	NE SE SW 32-6N-16W	1959	675	1439	Permian	(R 435)	240	+ 1004		
Kw-31	W. F. Collins No. 1 Frazier	SE SE SW 1-6N-15W	1956	347		Permian	(R 345)	2			
Kw-33	Malernee Oil No. 1 Cleveland	SW SW SE 11-6N-15W	1928	490	1412	Permian	410 S	80	+ 1002	CR	268
Kw-34	Roy Powell No. 1 Geis	NE NE SE 11-6N-15W	1956	313	1450	Permian	(R 238)	75	+ 1212		
Kw-35	Maco Prod. No. 1 Geis	NE SW SE 11-6N-15W	1956	460	1412	Permian	(R 450)	10	+ 962		
Kw-89	Beeler No. 1 Patton	NE NE NE 11-6N-15W		517	1434	Permian	430 S	87	+ 1004	CR	272

OGS County Number	Operator and Lease	Location	Date Drilled	Total Depth (feet)	Surface Elevation (feet)	Age of Overlying Strata	Depth to Top (feet)*	Thickness Penetrated (feet)	Elevation of top (feet)	Rock Group*	Petrographic Description on page
Kw-36	Kelly No. 1 Coker	NW NW SW 12-6N-15W	1956	504	1446	Permian	(R 472)	32	+ 974		
Kw-58	Maco Oil No. 1 Coker	NE SW SW 12-6N-15W	1957	468	1446	Permian	(R 465)	3	+ 981		
Kw-76	Russell & Sloan No. 1 Petty	14-6N-15W		500	1450±	Permian	495 S	5	+ 955	CR?	270
Gr-27	Abilene (Gled) Oil No. 1 Simpson	NE NE NE 11-5N-22W	1935	1261	1540	Permian	(R 1260)	1	+ 280		
Gr-28	Rogers Bros. No. 1 Graumann	NW NE 11-5N-21W	1948	996	1569	Permian	(R 994)	2	+ 575		
Gr-29	Winfrey & Walsh No. 1 Baumgart	NW SW 15-5N-21W	1948	1025	1519	Permian	(R 997)	28	+ 522		
Gr-65	Geo. T. Campbell No. 1 Hudson	NW NE NE 15-5N-21W	1960	1005	1545	Permian	(R 1004)	1	+ 541		
Gr-71	M. L. King No. 1 Windle	SE NW SE 15-5N-21W	1960	949	1490	Permian	(R 948)	1	+ 542		
Gr-72	M. L. King No. 2 Windle	NW NW SE 15-5N-21W	1960	885	1490±	Permian	(R 884)	1	+ 606		
Gr-30	Stephens Petr. No. 1 Johnson	SE SE NW 24-5N-21W	1945	910	1528	Permian	(R 897)	13	+ 631		
Gr-43	Gilliland & Delee No. 1 Crow	NE SE SE 32-5N-21W	1948	1612	1561	Permian	(R 1312)	300	+ 249		
Gr-31	Bolin Oil No. 1 Brown	SW NE SW 33-5N-21W	1948	1927	1571	Permian	(R 1260)	727	+ 311		
Gr-32	Copeland et al. (Stauffer) No. 1 Dillahunty	SE SE SE 36-5N-21W	1950	1019	1548	Permian	(R 1017)	2	+ 531		
Kw-103	G. K. Woods No. 1 Mitchell	SW SW NW 5-5N-19W	1958	678	1510±	Permian	(R 671)	7	+ 839		
Kw-38	Caudill-Bed Rock Partnership No. 1 Walker	SE SE SW 1-5N-18W	1921	1236	1494	Permian	(R 680)	556	+ 814		
Kw-40	Planteen No. 1 Bozman	SE SE NE 14-5N-18W	1940	1218	1218	Permian	(R 1052)	166	+ 166		
Kw-82	Morrow No. 1 Bozman	SE SE NE 14-5N-18W	1958	1218	1528	Permian	(R 525)	693	+ 1003	RMG	271

*See explanation, pages 180-181.

OGS County Number	Operator and Lease	Location	Date Drilled	Total Depth (feet)	Surface Elevation (feet)	BASEMENT ROCKS: Age of Overlying Strata	Depth to Top (feet)*	Thickness Penetrated (feet)	Elevation of Top (feet)	Rock Group*	Petrographic Description page
Kw-104	E. D. Willis No. 1 Rhea	NW NW SE 25-5N-18W	1958	312	1480±	Permian	(R 294)	18	+ 1186		
Kw-61	F. W. Bowdle No. 1 Hebensperger	NE NE NW 6-5N-17W	1957	587	1540	Permian	(R 585)	2	+ 955		
Kw-39	C. R. Porter No. 1 Sells	NE NE SE 11-5N-17W	1958	340	1526	Permian	(R 331)	9	+ 1195		
Kw-59	C. R. Porter No. 1 Sells	NE SE SW 11-5N-17W	1957	305	1521	Permian	(R 235)	70	+ 1286		
Kw-41	Lynch No. 1 Null	NE NE SE 18-5N-17W	1949	1447	1498	Permian	(R 670)	777	828		
Kw-112	J. N. Fidel No. 1 Farrar	NW SW NE 20-5N-17W	1959	533	1508	Permian	(R 455)	78	+ 1053		
Kw-117	Irrigation Products No. 1 Boydston	SW SE SW 31-5N-17W	1961	281	1475±	Permian	(R 265)	16	+ 1210±	WG	273
Kw-118	Irrigation Products No. 2 Boydston	SE SE SW 31-5N-17W	1961	232	1475±	Permian	(R 216)	16	+ 1259±		
Kw-42	Check No. 1 Hobbs	SE SE NW 35-5N-17W	1940	686	1526	Permian	(R 640)	46	+ 886		
Kw-55	John Fidel No. 1 Beirman	N½ NW NW 35-5N-17W	1958	218	1526	Permian	(R 217)	1	+ 1309		
Kw-43	Taylor & Lange No. 1 Beirman	NE NE SW 36-5N-17W	1957	215	1526	Permian	(R 200)	15	+ 1326		
Kw-62	J. H. Chalmers No. 1 Heller	SW NE SE 5-5N-16W	1957	566	1460	Permian	(R 515)	51	+ 945		
Kw-100	R. H. Darrow No. 1 Carter	NE NE SE 7-5N-16W	1960	485	1510±	Permian	(R 484)	1	+ 1026		
Kw-44	L. T. Payne No. 1 Graves	SE SE NW 10-5N-16W	1958	690	1447	Permian	(R 339)	341	+ 1108		
Kw-114	L. T. Payne No. 1 Rogers	NW NW SE 10-5N-16W	1958	390	1435±	Permian	(R 360)	30	+ 1075		
Kw-115	L. T. Payne No. 2 Rogers	NE NE SW 10-5N-16W	1958	250	1445±	Permian	(R 219)	31	+ 1226		
Kw-116	L. T. Payne No. 1 Grove	SE SE NW 10-5N-16W	1957	690	1445±	Permian	(R 330)	360	+ 1115		
Kw-60	L. L. Gage No. 1 Hunsinger	SW SW SE 15-5N-16W	1958	283	1480	Permian	(R 281)	2	+ 1199		
Kw-105	J. M. Bashara No. 1 Hampton	NE SW NW 22-5N-16W	1958	306	1493	Permian	(R 305)	1	+ 1188		
Kw-93	E. E. Flake No. 1 McClain	NW NE SW 26-5N-16W	1959	353	1545±	Permian	(R 351)	2	+ 1194		
Kw-101	Reinhart & Donovan No. 1 Hefner	SW SW SW 32-5N-16W	1960		1520±	Permian	less than 247' S			RMG	273
Kw-119	Shell Oil Co. No. 1 Lone Wolf Unit	C NE NE 4-5N-15W	1959	4398	1472	Cambrian	4355	43	- 2883	CR	273
Kw-98	Rex Whistler No. 1 Ahdokobo	NE NE NE 25-5N-15W	1959	204	1573	Permian	143 S & E	61	+ 1430	WG?	272
Kw-85	Wilcox Oil No. 1 Lee	NE NW SW 18-5N-14W	1959	316	1570	Basement rocks erroneously reported at 275' Basement expected at 5500'					
Gr-33	An-Son Petr. No. 1 Ware	SW NW NW 30-4N-22W	1952	4757	1706	Cambrian Arbuckle	4727 S	30	- 3021	WG	247
Gr-34	Stauffer No. 1 Beaucamp	C NE SE 1-4N-21W	1942	1117	1510±	Permian	(R 1105)	12	+ 405		
Gr-35	Abilene Oil (Gled) No. 1a Luker	SE SE SE 6-4N-21W	1935	2167	1512	Permian	2025 S	142	- 513	WG?	247
Jk-1	Tenn. Gas Trans. No. 1 Kinney	SW SW SW 23-4N-21W	1955	2293	1468	Permian	2191 S & E	102	- 723	WG	252
Jk-20	Reinhart & Donovan No. 1 Caves	NW NE 36-4N-21W	1940	1800	1462	Permian?	(R 1770)	30	- 308		
Jk-2	Robinson & Suppes No. 1 Walker	SW SW SW 19-4N-20W	1935	1600	1461	Permian	(R 1278)	- 322	+ 183		
Jk-23	Mitchell-Gage Drlg. No. 1 Dobbs	NE NW NE 35-4N-20W	1951	1082	1676	Permian	(R 1047?)	35	+ 629		
Kw-45	Taylor & Lange No. 1 Shaw	NW NE SW 4-4N-18W	1958	275	1465	Permian	(R 270)	5	+ 1195		
Kw-46	Hurst & Groth No. 1a Groth	SW SW SW 3-4N-16W	1940	395	1544	Permian	180 S	215	+ 1364	RMG	268
Kw-65	McWhirter, Walton, & Logan No. 1 Boyd	NW NW NW 4-4N-16W	1958	200	1521	Permian	(R 198)	2	+ 1323		

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Cm-1	Stanolind Oil & Gas No. 1 Perdasofpy	SE NW SW 11-4N-12W	1954	9674	1383	Cambrian Reagan	5420 E & S	4254	- 4037	CR 5420 to 8010 WG 8010 to 8625 NMBS 8625 to 9674	231
Cm-3	Benton Ross No. 1 McClung	SE NW NW 29-4N-12W	1949	315	1410±	Permian	(R 314)	1	+ 1096		
Gr-38	Harvey Drlg. No. 1 Barr	SE SE NE 2-3N-23W	1950	5305	1580	Cambrian Arbuckle	5304 S	1	- 3724	WG?	248
Gr-37	Bridwell Oil No. 1 Arnold	NE NW SE 5-3N-22W	1952	4548	1576	Permian	4490 S & E	58	- 2914	WG	247
Jk-4	McCasland-Wilcox Oil No. 1 Edwards	NW NW NE 9-3N-21W	1948	4413	1434	Permian	3594 E & S	819	- 2160	NMBS	252
Jk-5	Kilgore No. 1 Woolridge	SW SE NE 15-3N-21W	1935	2266	1419	Prob. too shallow for a basement test					
Jk-6	Russell No. 1 Daniel	NW NE SE 13-3N-20W	1936	1482	1458	Permian	1252 S	230	+ 206	WG	254
Jk-7	Lippert No. 1 Howard	SW NW 10-3N-19W	1939	1675	1431	Permian	(R 840)	835	+ 591	NMBS & WG	254
Jk-8	Burke-Greis Oil No. 1 Wright	NW SW 31-3N-19W	1935	1321	1378	Permian	1139 S	182	+ 239	WG	255
Jk-26	Schaffer Drlg. No. 1 Wright	NE NE SE 31-3N-19W	1959	1188	1384	Permian	1164 E & S	24	+ 220	WG	259
Jk-9	Gene Burke No. 1 Estes	SW SW NE 34-3N-19W	1941	1150	1402	Permian	830 S	320	+ 572	TM	255
Kw-47	Scarbrough & Henderson No. 1 Willis	NE NW SW 13-3N-17W	1949	1473	1378	Permian	(R 468)	1005	+ 910		
Kw-80	F. O. Hamilton No. 1 Cartwright	SW SE SE 36-3N-17W	1958	443	1375	Permian	(R 438)	5	+ 937		
Kw-95	Darby-Everest No. 1 Fullingin	NW NW SE 24-3N-16W	1959	173	1490	Permian	98 S	75	+ 1392	RMG	272
Kw-108	Frank Hampton No. 1 Woodward	NW NW NW 27-3N-16W	1959	560	1455±	Permian	(R 500)	60	+ 955		
Cm-2	Big Three Development No. 1 Dinse	SW NW NW 12-3N-12W	1955	629	1209	Permian	(R 620)	9	+ 589		
Cm-5	Tate, Fowler & Lawrence No. 1 Dinse	NW NW SW 12-3N-12W	1956	400	1184	Permian	(R 261)	139	+ 923		
Cm-6	Dixon Orig No. 1 Otippoby	NE NE 17-3N-11W	1956	1208	1150	Permian	(R 1179)	29	- 29		
Cm-8	Sinclair Oil & Gas No. 1 Ziegler	SW NW NW 33-3N-10W	1945	1827	1185	Permian	1740 E & S	87	- 555	CR	234
Cm-9	Mid Kansas Oil & Gas No. 1 Hendricks	SE SE 33-3N-10W	1926	2002	1185±	Permian	(R 1928)	74	- 743		
Cm-40	Garr-Wooley No. 2 Ryan	NE NE SE 34-3N-10W	1955	4303	1120	Permian	3812 S	491	- 2692	CR	236
Pc-2	Atlantic Oil & Ref. No. 1 Harvey	NW SE 27-3N-5E	1956	4807	1181	Cambrian Reagan	4795 E & S	12	- 3614	EAP	280
Jk-21	Smith No. 1 Mock	NW NE NW 23-2N-20W	1942	2630	1343	Cambrian	Not a confirmed basement test				
Jk-10	Columbian Fuel No. 1 Woolridge	NW NW SW 5-2N-19W	1957	1048	1362	Permian	(R 1046)	2	+ 316		
Jk-25	Schaffer Drlg. No. 1 Howard	SE SE SW 9-2N-19W	1959	959	1338	Permian	890 S	69	+ 448	TM	258
Jk-11	J. B. Russell No. 1 McWhorter	SE NE SW 25-2N-19W	1953	1580	1328	Permian	(R 1560)	20	- 232		
Jk-12	Clover Leaf Oil & Development No. 1 Crumpton	SW NE SE 28-2N-18W	1939	660	1309	Permian	(R 644)	16	+ 665		
Jk-22	Gutowski No. 1 Booker	NW NW NW 33-2N-18W	1937	1031	1351	Permian	820 S	211	+ 531	TM	257
Tl-37	Lippert No. 1 Miller	SE SW SW 19-2N-17W	1959	606	1310±	Permian	585 S	21	+ 725	RMG	291
Kw-83	O. P. Russell No. 1 Hicks	NW SW NW 5-2N-16W	1958	390	1390	Permian	(R 375)	15	+ 1015		
Kw-48	Gene Burke No. 1 Morganson	NW SW 6-2N-16W	1940	1035	1375	Permian	(R 485)	550	+ 890		
Kw-92	Frank Walton No. 1 Mockbray	W½ NW SW 30-2N-16W	1959	781	1425	Permian	(R 598)	183	+ 827		

*See explanation, pages 180-181.

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Kw-99	J. P. Day No. 1 McElroy	SW NW SW 30-2N-16W	1959	792	1420±	Permian	less than 500 S	292+		RMG	273
Kw-111	L. M. White & A. M. Wilburn No. 1 Boyd et al.	NW NW SE 30-2N-16W	1958	439	1260±	Permian	(R 410)	29	+ 850		
Kw-96	E. Resnick No. 1 Morris	SE NE SW 31-2N-16W	1959	1300	1326	Permian	(R 587)	713	+ 739		
Kw-49	Young Oil No. 1 Cook	NE NE NW 33-2N-16W	1936	677	1256	Permian	662 S	15	+ 594	NMBS	268
Kw-109	W. J. Holland No. 1 ------	SE NE SE 35-2N-16W	1959	683	1310±	Permian	(R 682)	1	+ 628		
Cm-10	Gates & Thurman No. 1 Carothers	SW NW NW 29-2N-15W	1953	404	1360±	Permian	(R 400)	4	+ 960		
Cm-11	Miller et al. No. 1 Weideman	SE SE NW 34-2N-12W	1934	306	1152	Permian	(R 305)	1	+ 847		
Cm-12	Ward Dayton No. 3 Ryan	NE NW NE 3-2N-10W	1956	2686	1160	Permian	2624 S	62	- 1464	CR	234
Cm-13	Ward Dayton No. 1 Schuman	N½ SW SW 10-2N-10W	1957	1320	1191	Permian	(R 1318)	2	- 127		
Cm-14	Garr & McCracken No. 1 Campbell	C SE NE 10-2N-10W	1942	1690	1166	Permian	(R 1672)	18	- 506		
Cm-15	W. H. Atkinson No. 1 Haldiman	NW NW NW 12-2N-10W	1954	3285	1107	Permian	3171 E	114	- 2064		
Cm-16	Westheimer & Daube No. 1 Thompson	SE SE 13-2N-10W	1927	2193	1093	Permian	(R 2185)	8	- 1092		
Cm-38	Esperado Mining No. 1 Wilson	SW NW NW 13-2N-10W	1953	2066	1121	Permian	(R 2058)	8	- 937		
Cm-17	Loggie Bros. et al. School Land	NE SW 17-2N-10W	1954	1118	1217	Permian	(R 857)	261	+ 360		
Cm-18	Dinsmore & Stipe No. 3 School Land	SW SE NE 20-2N-10W	1939	1062	1238	Permian	(R 1020)	42	+ 218		
Cm-19	Walter Riley No. 1 Fullerton	SW NE NE 21-2N-10W	1948	1057	1154	Permian	(R 1046)	11	+ 108		
Cm-20	Walter Riley No. 1 Wilson	NE NW SW 22-2N-10W	1955	1585	1159±	Permian	(R 1582)	3	- 423		
Cm-34	W. B. Dudley No. 1 Wilson	SE NE SW 22-2N-10W	1955	1586	1050	Permian	(R 1583)	3	- 533		
Cm-43	Fleet Drlg. No. 1 Meedville	SE SE SE 24-2N-10W	1951	2277	1135±	Permian	2065± S	212	- 930	CR	236
Cm-21	Palmer No. 22 Fee	SW NW NW 28-2N-10W	1948		1217	Permian	(R 1562)		- 345		
Cm-22	Hubbel, Wilson & Hampton No. 1 Allen	NE NE 28-2N-10W	1938	1028	1181	Permian	(R 1023)	5	+ 158		
Cm-44	Ashcraft & Palmer No. 3 Pope	28-2N-10W		2065	1180±	Permian	1665 S	400	- 485	CR	237
Cm-35	Franklin & Johnson No. 1 Keady	SE SW NW 29-2N-10W	1917	2570	1218	Cambrian Arbuckle?	(R 2050)	520	- 832		
Cm-23	Sinclair Prairie No. 1 Austin	NW SW SW 6-2N-9W	1942	4786	1161	Permian	4720 S	66	- 3559	CR?	235
Cm-24	Alladin Petr. No. 1 Schettler	C NE NE 9-2N-9W	1951	8373	1140	Permian	8285 S	88	- 7145	CR	235
Cm-32	W. H. Atkinson No. 1 Guthrie	NE SW NW 19-2N-9W	1952	3220	1103	Permian	2510 E	710	- 1407		
Cm-33	W. H. Atkinson No. 1 Coody	NW NW NW 21-2N-9W	1952	3996	1125	Permian	3950 E & S	46	- 2825	CR	236
St-1	Carter Oil No. 1 Williford	C SE NE 24-2N-9W	1951	10149	1160	Cambrian Reagan	8510 E & S	1639	- 7350	CR 8510 to 9810 NMBS 9810 to 10149	262
St-2	Carter Oil No. 1 Emmons	C SE NE 26-2N-9W	1948	7790	1185	Permian	6480 E & S	1310	- 5295	CR	283
St-14	Mid American Minerals No. 1 Tullous	NW NW NW 27-2N-9W	1959	5713	1129	Permian	(R 5528)	185	- 4399		
Cm-25	Magnolia Oil No. 5 Price	SE SW NE 30-2N-9W	1929	2655	1100±	Permian	(R 2550)	105	- 1450	CR	235
St-3	O. M. Pierce No. 1 Couch	NE NE SE 34-2N-9W	1954	3929	1162	Permian	3772 S	157	- 2610	CR	284
St-4	E. Fletcher No. 1 Richardson	SE SE SE 35-2N-9W	1954	4332	1135	Permian	(R 4178)	154	- 3043		

*See explanation, pages 180-181

OGS County Number	Operator and Lease	Location	Date Drilled	Total Depth (feet)	Surface Elevation (feet)	Age of Overlying Strata	Depth to Top (feet)*	Basement Rocks: Thickness Penetrated (feet)	Basement Rocks: Elevation of Top (feet)	Basement Rocks: Rock Group*	Basement Rocks: Petrographic Description (page)
St-5	Samedan Oil No. 1 Superior State	SW SE SW 36-2N-9W	1958	4297	1142	Permian	(R 4285)	12	- 3143		
Mr-3	Amerada Petr. No. 1 Hale	NE NW NE 19-2N-3E	1956	6297	1101	Cambrian Reagan	6162 E & S	135	- 5061	EAP	278
Pc-1	Gulf Oil No. 1 Emery	SW NE NE 15-2N-6E	1936	6600	968	Cambrian Reagan	6550 S	50	- 5582	EAP	280
Pc-4	Texfel Petr. No. 5 Patrick	C N½ NE NE 31-2N-7E	1960	8775	807	Cambrian Reagan	8740 S	35	- 7933	EAP	281
Jk-13	Gulf Oil No. 1 Inklebarger	SW SW SW 3-1N-20W	1939	2136	1349	Pennsyl-vanian	2135 S	1	- 786	CR	256
Jk-14	Gulf Oil No. 1 Lizzie	SE SE NW 4-1N-20W	1940	2588	1371	Pennsyl-vanian	2557 S	1	- 1186	WG	256
Jk-15	John Badger No. 1 Elliot	NE NE 5-1N-20W	1941	2697	1374	Pennsyl-vanian	2685 S	12	- 1311	WG	256
Jk-16	Gulf Oil No. 2 Fowler	NE NE SW 9-1N-20W	1941	2723	1332	Pennsyl-vanian	2722 S	1	- 1390	WG	257
Jk-27	Gypsy Oil No. 1 Kelly	NE NE NE 10-1N-20W	1933	2084	1330	Pennsyl-vanian	1925 S	159	- 595	CR	259
Jk-17	Gypsy Oil No. 1 Johnson	NW SW SE 11-1N-20W	1935	2017	1320	Pennsyl-vanian	1895 S	122	- 575	CR	257
Jk-28	Gulf Oil No. 1 Dosher	NE NE NE 14-1N-20W	1936	2210	1305	Pennsyl-vanian	(R 2187)	23	- 882		
Jk-18	Sun Oil No. 1 Wilson	NE NE SE 23-1N-20W	1956	3727	1353	Cambrian Reagan	3694 S	33	- 2341	NMBS	257
Jk-24	Stanley & Langford No. 1 Hickman	C NE SE 3-1N-19W	1947	1932	1318	Permian	(R 1929)	3	- 611		
Ti-1	Stanley & Langford No. 1 Young	NE NE NE 26-1N-19W	1947	1764	1288	Permian	(R 1762)	2	- 474		
Ti-2	W. C. Estes No. 1 Rigg	NE NE SE 2-1N-18W	1947	1000	1309	Permian	(R 975)	25	+ 334		
Ti-3	Tredwell & Stuenkel No. 1 Hash	N½ SW NE 9-1N-18W	1951	1595	1296	Permian	(R 765)	830	+ 531		
Ti-4	J. K. Wadley et al. No. 1-Capps	NW NW SW 10-1N-18W	1954	1085	1302	Permian	760 S	325	+ 542	TM	286
Ti-43	B. Waggoner No. 1 Kelly	NW NW NW 15-1N-18W	1920	1070	1290±	Permian	(R 775)	295	+ 515		
Ti-42	G. M. C. Drlg. No. 1 Wilson	SE NE NE 17-1N-18W	1955	1134	1290±	Permian	(R 950)	184	+ 340		
Ti-5	W. G. Gouchie et al. No. 1 Wilson	E½ NE NE 18-1N-18W	1947	1134	1291	Permian	1090 E	44	+ 201		
Ti-6	S. F. Hutcheson & E. Peterson No. 1 Wilson	NE NE NE 18-1N-18W	1947	1545	1289	Permian	(R 1120)	425	+ 169		
Ti-7	High Point No. 1 Richardson	SE SW NE 1-1N-17W	1954	670	1340	Permian	(R 669)	1	+ 671		
Ti-8	Long, Taylor, Akin & Rayzor No. 1 Grooms	SW NW 10-1N-17W	1929	740	1407	Permian	(R 738)	2	+ 669		
Ti-9	W. E. Miller No. 2 Williams	NW SE SW 13-1N-17W	1948	690	1265	Permian	(R 575)	115	+ 690		
Ti-38	Allen & Treadwell No. 1 Howell	SW SW NE 13-1N-17W		820	1270±	Permian	585 S	235	+ 685	RMG	291
Ti-39	Broday Oil No. 1 Howell	NW NW SE 13-1N-17W	1958	560	1270±	Permian	(R 558)	2	+ 712		
Ti-40	W. E. Miller No. 1 Williams	NW NE SW 13-1N-17W	1947	595	1272±	Permian	(R 578)	17	+ 694		
Ti-10	W. L. Hamilton No. 1 Webster	NW NE 14-1N-17W	1947	678	1306	Permian	(R 677)	1	+ 629		
Ti-36	F. Walters No. 1 Christy	NE NW SW 15-1N-17W	1958	756	1325±	Permian	(R 744)	12	+ 581		
Ti-11	J. W. Hastings No. 1 Warrick	NW NW NE 19-1N-17W	1955	1206	1381	Permian	(R 1096)	110	+ 285		
Ti-12	J. B. Russell No. 1 Goodwin	SE SE NW 21-1N-17W	1957	1133	1320±	Cambrian Arbuckle	1085 S	48	+ 235	TM	286
Ti-13	Honolulu Oil No. 1 Burba	NE NE NE 33-1N-17W	1945	2783	1276	Cambrian Reagan	2475 S	308	- 1199	TM	286
Ti-14	Morrison et al. No. 1 Burton	SW NE SE 34-1N-17W	1921	890	1236	Cambrian?	(R 848)	42	+ 388		

*See explanation, pages 180-181.

OGS County Number	Operator and Lease	Location	Date Drilled	Total Depth (feet)	Surface Elevation (feet)	Basement Rocks: Age of Overlying Strata	Depth to Top (feet)*	Thickness Penetrated (feet)	Elevation of Top (feet)	Rock Group*	Petrographic Description (page)
Ti-15	Buel & Herdon No. 1 Haught	SE SE NE 22-1N-16W	1935	841	1246	Permian	790 S	51	- 456	NMBS	287
Ti-41	Broday Oil No. 1 Patterson	SW SE NW 30-1N-16W	1958	561	1250±	Permian	(R 530)	31	- 730		
Cm-31	Palmer Drlg. (Winfrey et al.) No. 1 Sanders	SE SE NE 4-1N-15W	1947	727	1336	Cambrian	(R 726)	1	+ 610		
Cm-41	Gilliland No. 1 Clark	SW SW SE 21-1N-15W		806	1274	Permian	(R 805)	1	+ 469		
Cm-42	G. C. English No. 1 Worthen	N½ NW NW 3-1N-12W	1943	990	1132	Cambrian	(R 989)	1	+ 142		
Cm-26	W. E. McBroom No. 9 Long	SE SE NW 1-1N-11W	1954	1446	1110±	Permian? Cambrian?	(R 1350)	96	- 240		
St-6	P. Fletcher No. 1 Ball	NE NE NW 1-1N-9W	1952	4472	1056	Not a basement test (from sample examination)					
St-7	R. Bond No. 1 Kerbs	NW NW NE 2-1N-9W	1954	3865	1140	Permian	(R 3840)	25	- 2700		
St-8	California Company No. 1 Ketchum	SW NE SW 3-1N-9W	1951	3625	1181	Cambrian Reagan	3582 S	43	- 2401	CR	284
St-9	Travis Hedge No. 1 Roark	NW SE NE 3-1N-9W	1951	3275	1163	Permian	3248 S	27	- 2085	CR	285
St-10	Roland Bond No. 1 Calloway	SW SW SW 6-1N-8W	1956	4655	1155	Permian	(R 4611)	44	- 3456		
St-11	W. B. Cleary No. 1 Ing	NW NW SE 7-1N-8W	1957	4737	1142	Permian	4716 S	21	- 3574	CR?	285
Gv-10	Fain-Porter Drlg. No. 1 Mays Unit	C SW NE 9-1N-3W	1960	12781	969	Cambrian Reagan	7496 E & S	316 faulted	- 6527	CR	244
Gv-2	Potter Oil No. 7 Ringer	NW SW NW 19-1N-2W	1948	2208	975±	Cambrian Reagan	(R 2170)	38	- 1195		
Gv-3	Sunray Oil No. 1 Henderson	NE SE SE 19-1N-2W	1951	2495	975±	Cambrian Reagan	2455 E	40	- 1480		
Gv-4	Sunray Oil No. 3 Romine	NW NW SE 19-1N-2W	1948	3463	904	Cambrian Reagan	2630 E	833	- 1726		

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Gv-6	Sohio Petr. No. 1 Moore	SW SE NE 20-1N-2W	1956	5186	932	Cambrian Reagan	5091 E	95	- 4159		
Gv-7	Kilgore et al. No. 1 Williams	SE NE SW 20-1N-2W	1934	2705	893	Cambrian Reagan	2595 S	110	- 1702	CR	240
Gv-8	Sohio Petr. No. 1a Kennedy	NW NW SE 26-1N-2W	1947	9990	897	Cambrian Reagan	5597 E & S	4393	- 4700	CR 5597 to 8920 WG 8920 to 9990	241
Gv-1	Stanolind Oil & Gas No. 1 Allsup	C NW NW 34-1N-1W	1957	9943	947	Cambrian Reagan	9788 E & S	155	- 8841	CR	240
Mr-2	G. P. Caulkins No. 1 Turner Ranch	C NE NE 25-1N-4E	1956	3459	1209	Cambrian Reagan	3444 S	15	- 2235	EAP	277
Pc-3	G. P. Caulkins No. 1 Norris	SW SE 27-1N-5E	1955	3262	1160	Cambrian Reagan	3224 S	38	- 2064	EAP	280
Ti-30	W. J. Mosley No. 1 Kent-Willingham	SW SE NE 5-1S-19W	1950	2804	1250	Cambrian	(R 2798)	6	- 1548		
Ti-29	S. D. Johnson No. 1 Royse	SE SE SE 13-1S-17W	1947	1164	1183	Pennsyl-vanian	(R 1056)	108	+ 127		
Ti-17	H. R. Theck No. 1 Cox	SE SW NW 8-1S-16W	1947	924	1241	Pennsyl-vanian	(R 906)	18	+ 335		
Ti-18	Mid Continent Oil No. 1 Perry	SE SE SW 30-1S-16W	1947	1748	1189	Pennsyl-vanian	1491 S	257	- 302	TM	288
Ti-35	Mid Continent Oil No. 1 Overton	NW NE NW 33-1S-16W	1947	1721	922	Pennsyl-vanian	1668 S	53	- 746	TM	290
Ti-33	B. F. Weakley et al. No. 1 Fox	NE NE NE 7-1S-15W	1947	1592	1191	Pennsyl-vanian	(R 1577)	15	- 386		
Ti-34	Kingery Bros. No. 1 Smith	SE NE NE 15-1S-15W	1948	1555	1194	Pennsyl-vanian? Cambrian?	(R 1530)	25	- 336		
Ti-31	Cosden Petr. No. 1 Koos	SE SE NW 15-1S-15W	1919	1410	1250	Pennsyl-vanian?	(R 1400)	10	- 150		
Ti-32	E. V. George & D. Tankersley No. 1 Howell	SE SE NW 21-1S-15W	1954	1757	Not a basement test (from sample examination)						
Cm-29	Geo. Collins No. 1 Huddleston	NW NW SE 11-1S-14W		2052	1152	Cambrian	(R 2051)	1	- 899		

*See explanation, pages 180-181.

CGS County Number	Operator and Lease	Location	Date Drilled	Total Depth (feet)	Surface Elevation (feet)	BASEMENT ROCKS Age of Overlying Strata	Depth to Top (feet)*	Thickness Penetrated (feet)	Elevation of Top (feet)	Rock Group*	Petrographic Description (page)
Ti-19	S. D. Johnson No. 1 Strecker	SE SE NW 21-1S-14W	1946	1360	1188	Pennsyl- vanian	1358 E	2	- 170		
Cm-28	English Drlg. & Prod. No. 1 Coldran	SW NW NW 15-1S-13W	1947	3120	1148	Permian? Cambrian?	(R 2620)	500	- 1472		
Cm-36	Mid Kansas No. 1 Cox	NE SE NE 30-1S-13W	1926	1920	1078	Cambrian Arbuckle	1860 S	60	- 782	WG	236
Cm-45	Frankfort Oil No. 1 Pickins	C SW NW 7-1S-12W	1960	3437	1094	Cambrian Reagan	3432 S	5	- 2338	CR	237
Cm-30	Frankfort Oil No. 1 Poaf-py-Bitty	SW SW SW 4-1S-11W	1955	7230	1029	Cambrian Reagan	7200 E	30	- 6171	NMBS?	235
St-13	Jones Oil No. 9 Furst	NE SE NW 16-1S-8W	1952	8740	1190	Cambrian Reagan	8717 S	23	- 7527	CR	285
St-12	Lone Star Prod. No. 1 Beavers	SW NW SW 24-1S-7W	1958	11565	1122	Cambrian Reagan	11520 S	45	-10398	CR	285
Mr-4	Frankfort Oil No. 1 Freeman Heirs	NW NE SE 1-1S-1W	1956	14858	1138	Cambrian Reagan	4720 E & S	1030 faulted	- 3582	CR	278
Mr-5	Garr-Wooley No. 1 Anderson	SW SW SE 25-1S-1W	1955	2043	1380	Cambrian Reagan	(R 1898)	145	- 518		
Mr-1	Frankfort Oil No. 1 Sparks Ranch	C SE SE 32-1S-1W	1956	12884	1301	Cambrian Reagan	6830 E & S	6054	- 5529	CR 6830 to 11355 WG 11355 to 12884	274
Ti-20	Continental Oil No. 1 Smith	NW SE 6-2S-16W	1954	3373	1200	Pennsyl- vanian	3220 E	153	- 2020	TM	289
Ti-28	West Texas No. 1 Berry	C E½ W½ NW 10-2S-16W	1920	1500	1175±	Pennsyl- vanian	(R 1495)	5	- 320		
Ti-21	Sun Drlg. (Batson) No. 1 Parks	SW SW SW 11-2S-16W	1947	1972	1126	Cambrian Reagan	1915 S	57	- 789	TM & WG	289
Ti-22	R. O. Ray et al. No. 1 Madison	NW NW NW 11-2S-16W	1939	1894	1118	Cambrian Reagan	1870 S	24	- 752	TM & WG	290
Ti-23	S. D. Johnson No. 1 Kinder	NW NW NW 7-2S-15W	1950	2606	1127	Pennsyl- vanian	2550 E	56	- 1423		
Ct-1	Griffin No. 1 Russell	SE SE NW 16-2S-13W		2010	1101	Cambrian?	(R 1970)	40	- 869		
Ct-2	S. D. Johnson & Russell No. 1 Holmes	SW SW SW 20-2S-13W	1946	2295	1036	Pennsyl- vanian	(R 2244)	51	- 1208	TM	238
Ct-3	Ellison et al. No. 1 Harris	NW NE 26-2S-13W	1941	2296	1066	Cambrian?	2260± S	36	- 1194	TM	238
Jn-10	Gilmer Oil No. 2 Colvert	NW SW NW 2-2S-4E	not a basement test (by sample examination)								
Jn-15	Fain-Porter Drlg. No. 1 Peters	S½ NE NE 34-2S-8E	1961	1843	772	Granite on outcrop	(R 15)	750 faulted	+ 757	EAP	264
Ct-9	Christie-Stewart No. 1 Sanders	NE NE SE 15-3S-12W	1958	3402	1021	Cambrian Reagan	3380 S	22	- 2359	WG	239
Ct-4	Frankfort Oil No. 1 Phillips	SW SW SE 6-3S-11W	1955	4804	1045	Cambrian Reagan	4732 E & S	72	- 3687	CR	238
Jf-14	Magnolia Petr. No. 1 Gulf Fee	C NE SW 22-3S-5W	1959	6441	934	Cambrian Reagan	6410 S & E	31	- 5476	CR	261
Jn-1	Tom C. Greer No. 1 Harland	NW NW NE 33-3S-5E	1952	45	800±	Cretaceous Trinity	(R. 20)	25	+ 780±		
Jn-2	M. W. Bowers No. 1 Moore	SE SE SE 29-3S-8E	1950	144	750±	prob. not a basement test					
At-1	Wayne Roberts (Sutherland) No. 1 Ayers	NE NE SE 8-3S-9E	1952	101	Granite outcrop at surface						
At-6	State Oil No. 1 Collins	NE SE SE 25-3S-9E	1955	6140	621	Woodford (faulted)	580 S	598 faulted	+ 41	EAP	209
Ct-7	Kewanee Oil No. 12 Wook-kah-nah	E½ NE SW 1-4S-11W	1950	4287	946	Cambrian Reagan	4132 E & S	155	- 3186	CR	239
Ct-5	Amerada Petr. No. 1 Delana	SE NW NW 31-4S-9W	1929	3355	912	Cambrian Reagan	3275 S	80	- 2363	CR	238
Jn-3	McMillen & Allen No. 1 Brown	NW NE NW 11-4S-6E	1929	428	700±	Cretaceous Trinity	(R 427)	1	+ 273		
Jn-4	Shelton No. 1 Chapman	C NW NW 26-4S-6E	1938	3180	611	Cambrian	(R 3127)	53	- 2516		
Jn-14	Mars No. 1 Cravat	SE NE NW 9-4S-7E		405		Cretaceous Trinity	slush pit samples			EAP	263

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OGS County Number	Operator and Lease	Location	Date Drilled	Total Depth (feet)	Surface Elevation (feet)	Age of Overlying Strata	Basement Rocks: Depth to Top (feet)*	Basement Rocks: Thickness Penetrated (feet)	Basement Rocks: Elevation of Top (feet)	Basement Rocks: Rock Group*	Basement Rocks: Petrographic Description (page)
Jn-5	O. Wolff No. 1 Laughlin	SW 16-4S-8E	1943	216	635	Cretaceous Trinity	(R 215?)	1	+ 420		
Jn-6	Atlantic Ref. No. 2 Core Hole	NE NW 36-4S-8E		395	603	Cretaceous Trinity	(R 345)	50	+ 258	EAP	263
At-3	Shell Oil No. 4 Core Hole	14-4S-10E		203	600±	Cretaceous Trinity	195 S	8	+ 405±	EAP	209
At-5	Dillingham No. 1 Powledge	NW NE SE 19-4S-10E	1961	503	625	Cretaceous Trinity	(R 330)	173	+ 295		
At-4	Shell Oil No. 14 Core Hole	SW SW SW 20-4S-10E		330	580±	Cretaceous Trinity	325 S	5	+ 255±	EAP	209
At-2	Shell Oil No. 1 Core Hole	NW NW NW 26-4S-10E		338½	610±	Cretaceous Trinity	337 S	1½	+ 273±	EAP	209
Jf-1	Cities Service Oil No. 1 Gardner	SE SE NE 36-5S-9W	1946	3708	893	Pennsyl- vanian	3598 E & S	110	- 2705	WG	260
Jf-2	L. D. McMillan No. 1 Stanley	NW SE SE 30-5S-8W	1955	3707	914	Cambrian?	3552 E & S	155	- 2638	CR	260
Jf-3	Texhoma Prod. No. 1 King	NE NW SW 30-5S-8W	1958	3788	931	Cambrian	3744 S	44	- 2813	CR	260
Cr-1	Jones Oil No. 3 Wallace-Reed	NE NE NW 6-5S-1W	1959	12784	859	Cambrian Reagan	12620 S	164	-11761	CR	230
Jn-7	Haynes Oil No. 1 Overton	SE SE SE 6-5S-8E	1924	605	800±	Cretaceous Trinity	(R 548)	57	+ 252	EAP	263
Jn-13	Nyolka No. 1 Hood	NE NE NE 7-5S-8E	1921	566	775	Cretaceous Trinity	slush pit samples			EAP	263
Br-7	Willingham Drlg. No. 1 Buckman	SE NE 13-5S-8E	1953	690	675±	Cretaceous Trinity	(R 540)	150	+ 135±		
Br-10	Honeymon Drlg. (Kingwood) No. 1 Townsend	SE SE NW 30-5S-8E	1960	8107	706	Cretaceous Trinity	587 S	3653 faulted	+ 119	EAP	228
Br-1	R. W. Riddles No. 1 McCoy	SW NE NE 27-5S-10E	1921	763	653	Cretaceous Trinity	slush pit samples			EAP	221
Br-2	Phillips Petr. No. 1 Matoy	SW NW 24-5S-11E	1955	12514	695	Cretaceous Trinity	691 E & S	11823	+ 4	EAP	221
Jf-4	Magnolia Petr. No. 1 Spring	NE NW NE 25-6S-6W	1925	3453	874	Cambrian	(R 3395)	58	- 2521		
Jf-5	F. C. Hall No. 1 Spring	SW NE NW 26-6S-6W	1950	2955	879	Cambrian	(R 2950)	5	- 2071		
Jf-15	Sinclair Oil & Gas No. 1 Peterson	NW SW NE 32-6S-6W	1960	4666	876	Pennsyl- vanian	3883 E & S	783	- 3007	EAP	261
Br-3	T. T. Blakely No. 1 Coombs	SW NW NE 11-6S-9E	1928	921	555±	Cretaceous Trinity	(R 902)	19	- 352		
Br-5	A. T. Phillips No. 1 Hughes	SW NW NW 34-6S-11E	1954	881	580±	Cretaceous Trinity	(R 880)	1	- 300±		
Br-6	Sinclair Oil & Gas Strat. test	SE SE SE 28-6S-12E	1942		600±	Cretaceous Trinity	(R 965)		- 365±		
Jf-6	Bridwell Oil No. 1 Smart	NW SE 13-7S-6W	1944	2233	877	Pennsyl- vanian	2190 E & S	43	- 1314	EAP	260
Jf-7	Smart-Morgan et al. No. 1 Smart	SE SE NW 13-7S-6W	1951	2192	878	Pennsyl- vanian	(R 2190)	2	- 1312		
Jf-13	Van Eaton & Dunlap No. 1 Smart	NW SW SE 13-7S-6W	1958	2231	863	Pennsyl- vanian	(R 2175)	56	- 1312		
Jf-8	Texas No. 1 Smart	NE SE NW 14-7S-6W	1955	2367	850	Pennsyl- vanian	2320 E & S	47	- 1470	EAP	261
Jf-9	Hunter No. 1 Smith	SE NW NE 24-7S-6W	1947	2101	754	Pennsyl- vanian	2072 E	29	- 1318		
Jf-10	Hunter No. 1 Pfile	SE NE NE 24-7S-6W	1947	2157	754	Pennsyl- vanian	2041 E	116	- 1287		
Jf-16	Mack Oil Co. No. 1 Cox	NW SE NE 35-7S-6W	1962	5842	781	Cambrian	5760	82	- 4979	EAP	262
Jf-11	Humble Oil & Ref. No. 1 Jones	NE SE NW 18-7S-5W	1926	2270	811	Cambrian	(R 2243)	27	- 1432		
Jf-12	Humble Oil & Ref. No. 1 Alexander	NW NE NE 19-7S-5W	1926	1980	850±	Cambrian	(R 1924)	56	- 1074		
Br-9	Sinclair Oil & Gas No. 1 Everett Unit	NE NW NW 1-7S-9E	1961	7800	601	Cambrian	5610 E & S	2190	- 5009	EAP	226
Br-8	California Oil No. 1 Jones	NW NW NW 9-7S-10E	1961	8105	604	Cambrian	4270 S	3835	- 3666	EAP	225

*See explanation, pages 180-181.

APPENDIX B

Petrographic Descriptions of Thin Sections of Subsurface Samples

In the following appendix are given descriptions of 417 thin sections of cuttings and cores obtained from 178 wells drilled in the 17 counties of southern Oklahoma. All examinations were made by means of a Zeiss petrographic binocular microscope.

Standard thin sections were made from well cuttings, using the largest available chips for the thin-section mount. Generally these chips are one-fourth to one-half inch in greatest dimension. From this kind of sample a determination of mineral constituents and rock fabric may be satisfactorily made in the finer textured nonporphyritic rocks, but in coarser textured rocks and porphyries it is difficult or impossible to determine maximum grain sizes, mineral percentages, and ratios of groundmass to phenocrysts. Visual estimates alone normally have been made for these slides.

In selecting and interpreting the cuttings from a well, care has been taken to avoid contaminating rock fragments caved from above the bottom-hole samples. Many instances of obvious contamination can be easily recognized, yet some mixing of samples is unavoidable, especially in the deeper basement-rock penetrations by rotary drilling. Our interpretations of them are therefore partly subjective.

Oversize thin sections, either 2x2-inch or 2x3-inch, were utilized for most cores. They have yielded the most satisfactory interpretations, as they closely approximate outcrop samples and are amenable to analysis by the point-counting method of estimating mineral percentages or modes.

Index to Petrographic Descriptions

ATOKA COUNTY

SHELL OIL CORP., CORE HOLE No. 1 NW NW NW 26-4S-10E (At-2)

Granite...... Potassium feldspar, plagioclase, quartz, clay-zeolite, chlorite, sericite, iron ore. A highly altered small core chip; feldspars altering to clay, zeolite, and sericite; hematite as a vein stain; chlorite has completely replaced former mafic mineral. Grain size: 2 mm+. Texture: hypidiomorphic?

338' Core At-2-1

This appears to be highly altered Eastern Arbuckle Province granite located on the subsurface continuation of the Tishomingo uplift.

SHELL OIL CORP., CORE HOLE No. 4 14-4S-10E (At-3)

Granite...... Microcline (45%), quartz (30%), plagioclase (20%), biotite (3%), sericite (2%), iron ore (tr.), apatite (tr.). Exceptionally large microcline crystal with poikilitically enclosed feldspar and quartz; enclosed feldspar altered to clay and stained with hematite; cores of plagioclase much altered to sericite; olive-green biotite altering to a bluish-green (chloritic?) variety with minor interlayered iron ore; sericite altering from feldspars and associated with biotite. Grain size: to 6 mm. Texture: hypidiomorphic.

195-203' Core At-3-1

This well penetrated a less altered rock (than At-2) of the normal Tishomingo Granite of the Eastern Arbuckle Province.

SHELL OIL CORP., CORE HOLE No. 14 SW SW SW 20-4S-10E (At-4)

This well penetrated a highly altered dioritic rock, unsuitable for thin section examination. It is a rock of the Eastern Arbuckle Province.

STATE OIL, 1 COLLINS NE SE SE 25-3S-9E (At-6)

Granite porphyry(?)...... Plagioclase, microcline, quartz, calcite, chlorite, feldspar alterations, muscovite, iron ore, apatite, zircon. Several chips are microbreccias of granitic composition; possibly all the rock is a breccia, the "normal granite" chips representing the coarse breccia portions; quartz is generally strained; plagioclase is near An_{20} at the cores and more sodic at the margins; exceptionally large plagioclase crystals suggest that the rock is a porphyry; calcite veinlets are irregular. Grain size: greater than 6 mm. Texture: hypidiomorphic, cataclastic, and porphyritic(?).

670-690' Cuttings At-6-1

Granite..... Plagioclase, microcline, quartz, feldspar alterations, muscovite, chlorite-biotite, iron ore, sphene-leucoxene, calcite, apatite(?). Essentially similar to the previous sample; larger plagioclase crystals are faintly zoned; no microbreccia chips are present but cataclastic features are marked; plagioclase is clouded with alterations and contains some discrete muscovite flakes; microcline generally fresh; chlorite-biotite is found in small secondary(?) zones. Grain size: greater than 3.5 mm. Texture: hypidiomorphic and cataclastic.

760-770' Cuttings At-6-2

Granite...... Quartz, plagioclase, microcline, muscovite, chlorite-biotite, feldspar alterations, calcite, sphene-leucoxene, iron ore. Plagioclase contains cores and rims of highly turbid alterations; quartz is particularly abundant, probably because of sampling bias; muscovite flakes are secondary; iron ore is found only as dustlike particles; chlorite-biotite associated with muscovite; small amounts of myrmekitic intergrowth present; cataclastic linears and quartz straining are common. Grain size: greater than 4 mm. Texture: hypidiomorphic and cataclastic.

1100-1120' Cuttings At-6-3

State Oil, 1 Collins (cont.)

Granite of the Eastern Arbuckle Province was penetrated in this well. Shale of Mississippian age directly overlies the granite in fault contact, and shales of Atoka (Pennsylvanian) age were penetrated below a thrust fault at 1,178 feet. This is the second well penetrating a thrust fault on the north side of the Belton anticline. The cataclastic features are marked in this well, whereas they are virtually absent in the Fain-Porter 1 Peters (Jn-15), drilled a few miles to the northwest along the same fault zone.

BECKHAM COUNTY

THE PURE OIL CO., 1 TAUTE NW SE 34-10N-25W (Bk-1)

Micrographic granite porphyry...... Perthite (63%), quartz (31%), iron ore (4%), chlorite (1%), clacite (tr.), fluorite (tr.), zircon (tr.). Euhedral and subhedral phenocrysts of quartz and perthite surrounded by a radial micrographic intergrowth; perthite clouded with alterations and hematite dust; former mafic mineral, probably hornblende, completely replaced by chlorite; fluorite as a minor vein mineral; no free plagioclase noted. Grain size: to 3 mm. Texture: micrographic and porphyritic.

8020-8022'
Core
Bk-1-2

Micrographic granite porphyry...... Perthite (60%), quartz (31%), iron ore (4%), chlorite (3%), fluorite (1%), feldspar alterations (tr.), calcite (tr.), epidote (tr.), zircon (tr.). Relict amphibole altering to chlorite; perthite highly clouded with alterations and hematite dust; zircon associated with chlorite; fluorite as large intergranular crystals; epidote as groups of slender, small crystals; phenocrysts of perthite have rims of subradial micrographic intergrowth; no free plagioclase noted. Grain size: to 3 mm. Texture: micrographic and porphyritic.

8078-8080'
Core
Bk-1-3

This is the northernmost well penetrating rocks of the Wichita Granite Group.

TIDEWATER-SKELLY OIL CO., 1 BALDWIN SE NE NE 10-9N-25W (Bk-2)

Hornfelsic rhyolite porphyry...... Groundmass (88%), feldspar phenocrysts (8%), quartz phenocrysts (4%), chlorite, iron ore, calcite, sericite. Effects of metamorphism alter the original rhyolite by (1) silicification and recrystallization of groundmass quartz into areas of optically continuous units, enclosing finely granoblastic feldspar, and (2) development of micas in groundmass replacing feldspar. One quartz phenocryst has developed a rim of chlorite and iron ore as a rim 0.2 mm from the edge of the quartz; feldspar phenocrysts are highly altered and were not determined. Grain size: phenocrysts to 2 mm. Texture: relict porphyritic and granoblastic.

7280-7290'
Cuttings
Bk-2-5

Micrographic microgranite...... Potassium feldspar, quartz, plagioclase, chlorite, biotite, iron ore, calcite, sphene-leucoxene, sericite, fluorite, apatite, zircon. Delicate micrographic intergrowth has a feathery appearance in finer portions; plagioclase laths highly altered to sericite; high chlorite and biotite content apparently after hornblende; rock contains much sericite and calcite as replacement minerals. Grain size: to 1 mm. Texture: micrographic.

7390-7400'
Cuttings
Bk-2-1

Micrographic microgranite...... Potassium feldspar, quartz, plagioclase, chlorite, biotite, iron ore, clay-sericite, calcite, amphibole, sphene, apatite, zircon. Feldspars highly altered and difficult to determine; micrographic intergrowth delicate and feathery; chlorite and biotite apparently after an amphibole; small relict amphibole associated with iron ore; dusty hematite clouds feldspars. Grain size: to 0.5 mm. Texture: micrographic.

7423-7430'
Cuttings
Bk-2-2

Altered rhyolite porphyry...... Groundmass (83%), perthite phenocrysts (8%), quartz phenocrysts (6%), iron ore phenocrysts (3%), chlorite, calcite, feldspar alterations. Groundmass partially recrystallized to a xenomorphic mosaic of quartz and feldspar with relict patches of felted groundmass containing much hematite; areas of recrystallized quartz are optically continuous; perthite phenocrysts are highly altered, contain much hematite, and are embayed by groundmass and chlorite; minor veins of late feldspar; zircon and apatite not present. Grain size: phenocrysts to 3 mm. Texture: porphyritic, xenomorphic, and relict felted.

7470-7480'
Cuttings
Bk-2-3

Tidewater-Skelly Oil Co., 1 Baldwin (cont.)

Altered rhyolite porphyry...... Groundmass (81%), quartz phenocrysts (13%), perthite phenocrysts (6%), sericite, chlorite, iron ore, biotite,
7535-7550' sphene. Recrystallized groundmass is a xenomorphic mosaic of
Cuttings quartz and feldspar without relict felted portions; feldspar in
Bk-2-4 groundmass is clear and unaltered; areas of groundmass feldspar are irregularly but completely replaced by sericite; quartz phenocrysts embayed and feldspar phenocrysts contain much sericite; iron ore and chlorite in small intergranular masses. Grain size: phenocrysts to 2.5 mm. Texture: porphyritic, with xenomorphic groundmass.

The rhyolite in the upper part of the well is considered to have been altered by the microgranite intrustion (Bk-2-2, 3). The lower rhyolites, beneath the microgranite, show less recrystallization effects but have definitely been reconstituted to some extent, with sericitization of feldspars important in Bk-2-4. The rhyolites are believed to be an erosional relict of the Carlton Rhyolite Group that once covered the entire area. The microgranite, though not typical, is part of the Wichita Granite Group.

UNITED CARBON & SKELLY, 1 WOOTEN UNIT SW NE NW 11-9N-25W (Bk-3)

Micrographic granite porphyry(?)...... Perthite (59%), quartz (29%), plagioclase (3%), iron ore (4%), calcite (3%), chlorite (1%), sphene (tr.),
7760-7775' apatite (tr.), zircon (tr.), epidote (tr.). Feldspars dusty with
Cuttings hematite and minor alterations; nonintergrown feldspar with
Bk-3-1 plagioclase core may represent phenocrysts; former amphibole is completely altered to chlorite-calcite-hematite masses; one chip contains minor breccia vein; micrographic intergrowth delicate to coarse cuneiform. Grain size: to 2.5 mm. Texture: micrographic and porphyritic(?). A typical rock of the Wichita Granite Group.

A. R. JORDAN, 1 CAUDILL ESTATE SE SE SE 27-9N-25W (Bk-4)

Granite...... Perthite, quartz, iron ore, biotite, sphene, feldspar alterations, zircon. String-type perthite is clouded with hematite dust and
Depth? alterations; one clot of biotite, sphene, magnetite, and zircon
Core contains all accessory minerals in the slide. Grain size: to 3 mm.
Bk-4-1 Texture: hypidiomorphic.

This slide was loaned by the Pan American Petroleum Corporation and the depth is not given. The rock is a representative of the Wichita Granite Group.

V. J. DEVINE ET AL., 1 WATSON NE NE 34-9N-25W (Bk-5)

Granite...... Perthite, quartz, iron ore, biotite, fluorite, sphene, apatite. Because of the coarseness of the granite and the small size of the
3340-3350' chips, mineralogic estimation is impossible; perthite clouded with
Cuttings hematite dust and alterations; near margins of large quartz crystal
Bk-5-1 is a small amount of micrographic intergrowth; sphene associated with biotite and in masses of small granules; fluorite appears to be late magmatic and is intergranular with the biotite; biotite is both reddish brown and olive green. Grain size: to 5 mm. Texture: hypidiomorphic and sparsely micrographic.

V. J. Devine et al., 1 Watson (cont.)

Granite...... Perthite (65%), quartz (31%), biotite (2%), iron ore (2%), fluorite (tr.), apatite (tr.), zircon (tr.). Clotted intergranular biotite,
3400-3410' apatite, fluorite, and zircon with some hematite stain; biotite also
Cuttings enclosed in perthite; perthite clouded with alterations and hematite
Bk-5-2 dust. Grain size: to 6 mm. Texture: hypidiomorphic and sparsely micrographic.

Granite...... Perthite (66%), quartz (29%), iron ore (2%), chlorite (1%), biotite (1%), feldspar alterations (tr.), zircon (tr.). Minor intergrown
3600-3620' quartz and feldspar near margins of large quartz crystals; no free
Cuttings plagioclase noted; biotite altering to chlorite and associated with
Bk-5-3 magnetite; zircon grains discrete. Grain size: to 4+ mm. Texture: hypidiomorphic and sparsely micrographic.

The cuttings in the lower portion of this well are excellent and approach core-chip size. The granite is a good example of the Wichita Granite Group and is most like typical Lugert granite of the western Wichita Mountains.

PHILLIPS PETR. CORP., 1 NANCE SE SE NW 8-7N-23W (Bk-6)

Granite...... Perthite (61%), quartz (28%), plagioclase (3%), biotite (3%), iron ore (2%), chlorite (1%), calcite (1%), amphibole (tr.), sericite (tr.),
2216-2227' sphene (tr.), apatite (tr.), clay (tr.), zircon (tr.). String-type
Cuttings perthite contains patches of free plagioclase altering to sericite;
Bk-6-1 biotite development in breccia veins with calcite and some clay; one chip composed of oriented sodic plagioclase and book biotite of questionable origin. Grain size: to 1.3 mm. Texture: hypidiomorphic.

Quartz diorite...... Plagioclase (61%), hornblende (13%), quartz (9%), biotite (7%), iron ore (3%), sphene (2%), apatite (2%), sericite (tr.),
2240-2247' chlorite (1%), calcite (tr.), potash feldspar? (tr.). Sodic andesine
Cuttings (An_{33}) laths altering to sericite; highly altered potash feldspar or
Bk-6-2 untwinned plagioclase present; biotite is fresh and red brown, with minor inter-layered chlorite and associated sphene granules; hornblende is well crystallized, fresh and partly intergranular. Grain size: to 1 mm. Texture: hypidiomorphic.

Diorite...... Plagioclase (38%), biotite (32%), sphene (13%), chlorite (12%), iron ore (2%), calcite (1%), apatite (tr.), sericite (tr.), zeolite (tr.).
2280-2290' Several large biotite crystals contain poikilitically enclosed
Cuttings intermediate andesine laths; biotite contains minor interlayered
Bk-6-3 chlorite with associated sphene granules as an alteration product; well-crystallized sphene is intergranular and optically continuous over an area 5 mm in diameter; andesine altering to sericite and minor zeolite; chips range widely in mineral percentages indicating that the mafic constituent is segregated into clots. Grain size: to 3 mm. Texture: hypidiomorphic and poikilitic.

Wichita granite intrudes the older diorite as a dike or sill. The diorite is in the Raggedy Mountain Gabbro Group and is similar to rocks penetrated in nearby wells.

LEWIS DRLG. CO., 1 GARRETT NE NE NE 11-7N-25W (Bk-7)

Microgranite porphyry...... Perthite, quartz, plagioclase, chlorite, iron ore, sericite, calcite, biotite, zircon, apatite. A fine-grained altered
2206-2225' rock, difficult to estimate without staining and etching; free
Cuttings plagioclase altering to sericite, particularly in cores of crystals;
Bk-7-1 calcite replaces portions of feldspar; zircons both as large crystals and numerous tiny crystals, suggesting two generations; biotite

Lewis Drlg. Co., 1 Garrett (cont.)
fresh to completely replaced by chlorite; hematite as veinlets and stain with some reorganized biotite associated with abundant iron oxide. Grain size: to 1 mm. Texture: hypidiomorphic.

A fine-grained marginal phase of the Wichita granite, located near the boundary with the Raggedy Mountain Gabbro Group.

TAYLOR, 1 FEE NW NW SE 27-7N-25W (Bk-8)

Rhyolitic tuff...... Matrix and reconstituted lithic fragments (63%), plagioclase (16%), quartz (9%), perthite (6%), iron ore (2%), chlorite (2%), epidote (1%), sericite (tr.), zircon (tr.), sphene (tr.). Clastic fragments of plagioclase, perthite, and quartz cemented in a quartz-feldspar matrix; this matrix also contains reconstituted lithic fragments, locally showing relict structure; matrix-detritus boundaries are partially sutured; large quartz fragments are generally shattered and some smaller grains have shardlike concave surfaces; epidote as a replacement in feldspar fragments and as secondary crystalline masses in matrix; iron ore associated with masses of pennine-type chlorite and as clastic fragments. Grain size: to 1.5 mm. Texture: relict clastic.

2770-2795'
Cuttings
Bk-8-1

This rhyolitic tuff indicates an extrusive origin for at least part of the large tract of rhyolites in Beckham and western Greer Counties. The reconstitution of the matrix and the introduction of epidote is related to a younger rhyolite flow or granite intrusion. The tuff is a member of the Carlton Rhyolite Group.

STEPHENS PETR. CO., 1 PENNINGTON NW NW NW 27-8N-25W (Bk-10)

Diorite...... Plagioclase (56%), hornblende (16%), biotite (11%), pyroxene (5%), iron ore (4%), quartz (3%), chlorite (2%), sericite (1%), calcite (1%), sphene (tr.). Variability of mineral composition and percentages among chips; quartz intergranular and apparently primary; pyroxene contains iron ore granules and is not present in all chips; biotite is reddish brown and altering to chlorite and sphene, indicating a titaniferous variety; calcic andesine (An_{40}) altering to sericite. Grain size: to 2 mm. Texture: hypidiomorphic.

2240-2260'
Cuttings
Bk-10-1

A diorite of the Raggedy Mountain Gabbro Group, similar to rocks penetrated in nearby wells.

SHELL OIL CORP., 1 RANDLE C SE SW 15-9N-23W (Bk-12)

Micrographic granite porphyry...... Perthite (66%), quartz (28%), iron ore (3%), chlorite (2%), calcite (tr.), feldspar alterations (tr.), fluorite (tr.), sphene (tr.), zircon (tr.). Perthite clouded with alterations and iron ore dust; delicate micrographic intergrowth with long quartz rods subradial around perthite phenocrysts; alteration masses of sphene, calcite, and iron ore or chlorite and calcite after a mafic mineral; fluorite in veinlets, in part associated with chlorite and magnetite. Grain size: to 2.5 mm. Texture: micrographic and porphyritic.

4190-4250'
Cuttings
Bk-12-1

Micrographic granite porphyry...... Perthite (66%), quartz (30%), iron ore (3%), feldspar alterations (tr.), chlorite (tr.), calcite (tr.), fluorite (tr.), sphene (tr.), zircon (tr.). Basically similar in texture and mineralogy to the previous sample; chlorite in small masses of shreds, suggesting an initially low femic content; fluorite in veinlets with late iron ore; perthite clouded with hematite dust and minor alterations. Grain size: to 1.8 mm. Texture: micrographic and porphyritic.

4285-4300'
Cuttings
Bk-12-2

Located near the fault bounding the south flank of the Anadarko basin, the rock is typical of the Wichita Granite Group.

PHILLIPS PETR. CO., 1 MARTIN C NW NE 27-9N-23W (Bk-13)

Granite...... Sample too poor for thin-section examination. The top of the basement rock in this well is indefinite but cannot be lower than 4,300 feet.

ROGERS-FAIN, 1 WINDLE SE NW SE 31-9N-23W (Bk-14)

Micrographic granite...... Perthite (62%), quartz (36%), sericite (1%), iron ore (1%), chlorite (tr.), biotite (tr.), fluorite (tr.), zircon (tr.). Perthite irregularly clouded with alterations and hematite dust; granular mosaic of iron-stained biotite in small masses; exceptionally small biotite books irregularly distributed; coarse sericite flakes locally after perthite; quartz in micrographic intergrowth and coarser intergranular crystals. Grain size: to 1.2 mm. Texture: micrographic.

6430-6440'
Cuttings
Bk-14-1

Micrographic granite porphyry...... Perthite (64%), quartz (34%), iron ore (1%), clay-sericite (tr.), biotite (tr.), zircon (tr.). Suggestion of microcline in perthite but clouding by alterations and hematite dust make identification impossible; quartz in micrographic intergrowth as well as larger intergranular crystals; chlorite noticeably absent; zircons in tiny crystals somewhat metamict. Grain size: to 1.4 mm. Texture: micrographic and porphyritic.

6470-6489'
Cuttings
Bk-14-1

The rock in this well is typical of the finer grained varieties of the Wichita Granite Group.

GULF OIL CORP., 1 BACK NW SE 34-9N-22W (Bk-18)

Granite...... Microcline perthite (59%), quartz (39%), biotite (0.8%), riebeckite (0.5%), iron ore (0.4%), sphene (0.3%), zircon (tr.), fluorite (tr.). Cataclastic zones traverse slide and contain mineral relicts in a highly iron-stained clay paste; microcline well twinned in a string-type perthite; large quartz crystals, partially strained and shattered, with iron ore introduced along cracks; riebeckite as small acicular crystal inclusions in the perthite as well as larger well-formed crystals. Grain size: to 6 mm. Texture: hypidiomorphic and cataclastic.

8012'
Core
Bk-18-1

For chemical analysis of this rock see table 18.

This well penetrated a surprisingly homogeneous granite of the Wichita Granite Group. The occurrence of microcline perthite and riebeckite is unusual but similar types of granite, although rare, crop out in the Wichita Mountains. The cores taken from this well show that subparallel brecciation zones are common. An exceptionally thick sequence of granite wash overlies the basement. This arkose is apparently coarse and conglomeratic. It contains almost no iron stain, resulting in a curious and deceptive white color.

BIG CHIEF DRLG. CO., 1 WEAVER SW SW NE 8-8N-22W (Bk-19)

Micrographic granite...... Perthite (61%), quartz (34%), iron ore (3%), biotite (1%), feldspar alteration (tr.), calcite (tr.), sphene (tr.), apatite (tr.), zircon (tr.). Perthite clouded with hematite dust and minor alterations; quartz intergrown with perthite or allied optically to intergrowth; yellowish-red biotite as an intergranular mineral and in small patches; sphene associated with iron ore; zircon somewhat metamict. Grain size: to 2 mm. Texture: micrographic.

2000-2010'
Cuttings
Bk-19-1

Big Chief Drlg. Co., 1 Weaver (cont.)

Micrographic granite...... Perthite (61%), quartz (35%), iron ore (2%), biotite (1%), clay-sericite (tr.), fluorite (tr.), chlorite (tr.), calcite (tr.), apatite (tr.), zircon (tr.), sphene (tr.). Clouded perthite in a delicate micrographic intergrowth with quartz; magnetite clots contain apatite, zircon, and fluorite concentrations; original olive-green biotite stained with hematite; one cataclastic vein contains clay-sericite paste. Grain size: to 3 mm. Texture: micrographic.

2200-2205'
Cuttings
Bk-19-2

A typical micrographic variety of the Wichita Granite Group.

GULF OIL CORP., 1 DAY SE NE SE 12-8N-22W (Bk-20)

Granite...... Microcline perthite (62%), quartz (34%), calcite (2%), iron ore (1%), feldspar alterations (tr.), riebeckite (tr.), biotite (tr.), sphene (tr.), apatite (tr.). Microcline in string-type perthite; calcite replaces original minerals irregularly; magnetite altering to hematite; one small riebeckite crystal altering to biotite; magmatic accessory exceptionally sparse. Grain size: to 3 mm. Texture: hypidiomorphic.

2200-2220'
Cuttings
Bk-20-1

Micrographic granite porphyry...... Microcline perthite (62%), quartz (33%), calcite (3%), iron ore (1%), sericite (tr.), biotite (tr.), epidote (tr.), chlorite (tr.), zircon (tr.), apatite (tr.). String-type microcline perthite clouded with minor hematite dust and alterations; calcite common along breccia zones and as an intergranular replacement; zircon unusually abundant and numerous as small stubby and longer slender crystals; micrographic intergrowth poorly developed locally. Grain size: to 1.5 mm. Texture: micrographic and porphyritic.

2580-2600'
Cuttings
Bk-20-2

The general area seems to be characterized by microcline perthite, such as is found in the Gulf Oil Corp., 1 Back, three miles to the northwest. The micrographic intergrowth is poorly developed and is probably a phase of the normal hypidiomorphic texture. The rocks are representative of the Wichita Granite Group.

A. SILBERMAN, 1 VAN VACTER NW SE SE 24-8N-22W (Bk-21)

Micrographic granite porphyry...... Perthite (61%), quartz (36%), plagioclase (1%), iron ore (1%), biotite (tr.), feldspar alterations (tr.), sphene (tr.), apatite (tr.), zircon (tr.). Sparse phenocrysts of sodic plagioclase and perthite; plagioclase highly sericitized; minor hematite along cracks; small, anhedral, olive-green biotite partly associated with magnetite. Grain size: to 2 mm. Texture: micrographic and porphyritic.

1560-1570'
Cuttings
Bk-21-1

This rock is typical of the granites found in numerous wells in this area and of the Wichita Granite Group.

MID AMERICAN, 1 BRISCOE SW SW SW 28-8N-22W (Bk-26)

Diabase cutting gabbro...... Plagioclase, pyroxene, biotite, iron ore, hornblende, chlorite, clay-zeolite, quartz, apatite. Plagioclase has very poorly defined twinning; red-brown biotite appears to be primary and is altering to green biotite or chlorite; pyroxene in small clouded granules containing a small amount of iron ore. Grain size: to 0.5 mm. Texture: intersertal.

2657-2669'
Cuttings
Bk-26-1

This well penetrated rock of the Raggedy Mountain Gabbro Group. Samples from this group were unsuitable for thin-section examination and the diabase intruding the gabbro was the only material that could be petrographically examined.

CARTER OIL CO., 1 STATE TAYLOR C SW SW 31-9N-21W (Bk-30)

Micrographic granite porphyry...... Perthite (66%), quartz (29%), chlorite (3%), sphene-leucoxene (1%), iron ore (tr.), epidote (tr.), feldspar alterations (tr.), zircon (tr.), fluorite (tr.), apatite (tr.). Discrete perthite crystals as euhedral to subhedral phenocrysts; epidote associated with sphene-leucoxene masses; zircon unusually abundant and somewhat metamict; perthite is possibly microcline type but clouding by alterations makes determination impossible; sphene-leucoxene masses appear to be after titaniferous magnetite. Grain size: to 2.5 mm. Texture: micrographic and porphyritic.

6860-6870'
Cuttings
Bk-30-1

Sedimentary rocks of lower Paleozoic age (Viola Limestone) were penetrated beneath the granite described above. The thrust fault separating these rocks is a zone from 7,412 feet to 7,463 feet and appears to be a highly mixed brecciated rock containing fragments of granite and the underlying sedimentary rocks. The presence of two diabase dikes in the granite mass offer unequivocal evidence for the in situ character of the granite. The thrust fault penetrated in this well is believed to be one of the major faults bounding the north flank of the Wichita uplift. The granite is part of the Wichita Granite Group.

WOOD PETR. & ROYALTY CO., 1 BLAIR C NW SE 32-9N-26W (Bk-40)

Granite...... An example of the Wichita Granite Group; samples unsuitable for petrographic examination.

PIERCE OIL CO., 1 PRATH SE SE NE 21-8N-26W (Bk-41)

Granite porphyry(?)...... Perthite, quartz, plagioclase, iron ore, chlorite, sphene, epidote, amphibole, apatite. Small size of chips and relative coarseness of the rock make textural relations obscure; patch- and string-type perthite contain dusty hematite; amphibole altering to chlorite with minor sphene; some chlorite in chertose quartz veins; quartz appears highly strained; a slide prepared from a greenish rock at this interval indicates a highly chloritic, perhaps mylonized rock. Grain size: to 2.5 mm. Texture: hypidiomorphic, possibly porphyritic and cataclastic.

2438-2450'
Cuttings
Bk-41-1

This is the westernmost example of the Wichita Granite Group in Oklahoma. The cataclastic effects are possibly caused by the fault separating this well from the Domac Oil Co., 1 Sanders (Bk-50), a few miles to the northeast.

CARTER & BUD LEWIS, 1 BINGHAM C NE NE 31-8N-26W (Bk-42)

Diorite...... Plagioclase (59%), hornblende (19%), iron ore (8%), biotite (7%), pyroxene (4%), chlorite (1%), sericite-zeolite (tr.), calcite (tr.), apatite (tr.). Plagioclase laths, probably intermediate anadesine, are strongly zoned and contain apatite and opaque needle inclusions; hematite in veins and after magnetite; deep red-brown biotite associated with olive-green hornblende; pale-green pyroxene contains iron-ore granules. Grain size: to 1.5 mm. Texture: hypidiomorphic.

2152-2164'
Cuttings
Bk-42-1

This rock is a good example of the subsurface diorites of the Raggedy Mountain Gabbro Group.

JO GAIL, 1 GILLILAND NE NE NE 33-8N-26W (Bk-43)

Olivine gabbro and quartz gabbro...... Plagioclase, pyroxene, biotite, hornblende, iron ore, quartz, olivine, sphene, calcite, apatite, chlorite, rutile(?). Intermediate labradorite (An_{57}) contains needle inclusions of rutile(?); olivine occurs in chips not containing quartz; quartz is intergranular and appears primary; magmatic

2285-2294'
Cuttings
Bk-43-1

Jo Gail, 1 Gilliland (cont.)

hornblende as a reaction product around pyroxene; red-brown biotite occurs in all chips and is exceptionally well crystallized; variation in rock type may be due to improper sampling or extreme local variation in rock type. Grain size: to 2 mm. Texture: hypidiomorphic.

Brecciated granite porphyry...... Perthite, quartz, plagioclase, iron ore, biotite, sericite, sphene, calcite, apatite, zircon. Rock is too coarse for accurate estimation of mineral percentages; minor sericite in feldspars that are otherwise remarkably clear; in breccia zones feldspar and quartz are shattered, biotite books are bent, and veins are reduced to chertose mylonized mosaic; large phenocryst of sodic oligoclase; biotite altering to chlorite with granular sphene as a byproduct. Grain size: to 5 mm. Texture: hypidiomorphic and porphyritic.

2387-2395'
Cuttings
Bk-43-2

Gabbro...... Plagioclase (52%), pyroxene (24%), biotite (14%), hornblende (5%), iron ore (4%), quartz (1%), feldspar alterations (tr.), apatite (tr.), acicular inclusions (tr.). Strongly zoned to unzoned bytownite (An_{73}) contains acicular inclusions that may be rutile in part; finely fibrous biotite shreds replace plagioclase in veins and patches; most biotite appears secondary but primary red-brown biotite is present in books; pyroxene contains iron ore granules and rods and is mottled with hornblende as a reaction product; hornblende also as discrete primary crystals; quartz as a minor but primary mineral; apatite well developed. Photomicrograph, pl. XIII-5, -6. Grain size: to 2.2 mm. Texture: hypidiomorphic.

2505-2515'
Cuttings
Bk-43-4

The granite (Bk-43-2) is an intrustion of the Wichita Granite Group into the older Raggedy Mountain Gabbro Group. The gabbros in this well are higher in biotite than the normal gabbro of the outcrop, suggesting transition to the dioritic varieties found in extreme western Oklahoma.

KROY AMERICAN OILS, 1 FRANCIS SW SW NE 7-7N-26W (Bk-44)

Quartz diorite...... Plagioclase (56%), hornblende (13%), biotite (8%), pyroxene (7%), quartz (6%), iron ore (5%), chlorite (1%), sphene (2%), calcite (tr.), sericite (tr.), apatite (tr.), zircon (tr.), rutile? (tr.). Some plagioclase zoned and contain needle inclusions of rutile(?) and is sodic andesine (An_{34}); red-brown biotite altering to a blue-green variety; pyroxene contains iron-ore granules and is somewhat clouded; chips having the least quartz have the most pyroxene but all chips contain both; zircons are numerous; hornblende is olive green to blue green and is well crystallized. Grain size: to 2 mm. Texture: hypidiomorphic.

3275-3285'
Cuttings
Bk-44-1

Diorite...... Plagioclase (50%), biotite (18%), pyroxene (15%), iron ore (7%), hornblende (6%), quartz (2%), clay-sericite (2%), apatite (tr.). Plagioclase appears to be andesine and is altering to clay-sericite; both clinopyroxene and orthopyroxene are present with schiller iron ore in the orthopyroxene; red-brown biotite associated with pyroxene; hornblende content variable; quartz present in all chips and is apparently primary. Grain size: to 1.5 mm. Texture: hypidiomorphic.

3330-3335'
Cuttings
Bk-44-2

Diorite...... Plagioclase (51%), pyroxene (21%), biotite (9%), iron ore (7%), hornblende (4%), chlorite (4%), sphene-leucoxene (2%), feldspar alterations (2%), apatite (tr.), quartz(?) (tr.). Laths of intermediate andesine altering along a vein and in masses to a clay-sericite-zeolite mixture; chlorite and fibrous green biotite replace portions of the pyroxene; biotite also in well-crystallized red-brown books; pyroxene contains schiller and granule iron ore. Grain size: to 2 mm. Texture: hypidiomorphic.

3420-3425'
Cuttings
Bk-44-3

Kroy American Oils, 1 Francis (cont.)

An important well which, like the Barnes, 1 Gamble (Bk-57), has sufficient depth penetration to show downward gradation of quartz diorite into normal diorite, evidently the result of differentiation of gabbroic magma in a large chamber. The diorites are typical representatives in the western area of the Raggedy Mountain Gabbro Group.

DOMAC OIL CO., 1 SANDERS NE SE 35-9N-26W (Bk-50)

Granite porphyry...... Perthite (52%), quartz (29%), plagioclase (14%), iron ore (2%), chlorite (1%), biotite (1%), sphene (tr.), zircon (tr.). String- and patch-type perthite with small amounts of clouding by hematite dust; albite fresh and unaltered; phenocrysts are irregularly shaped perthite; biotite altering to chlorite and sphene; zircon and biotite associated with iron ore. Grain size: to 3 mm. Texture: hypidiomorphic and porphyritic.

7740-7750'
Cuttings
Bk-50-1

This well penetrated a representative of the Wichita Granite Group.

RAMSEY, 1 GARRETT NW SE SE 34-8N-21W (Bk-53)

Gabbro...... Plagioclase, chlorite, calcite, feldspar alterations, iron ore, biotite, sphene, apatite, acicular inclusions. Calcic labradorite generally fresh but cut by veinlets of calcite and clay-zeolite; former mafic minerals completely altered to chlorite and calcite; apatite exceptionally large and well formed; inclusions in plagioclase appear formless. Grain size: to 4 mm. Texture: hypidiomorphic.

1666'
Cuttings
Bk-53-1

The alteration is characteristic of the more mafic-poor rocks of the Raggedy Mountain Gabbro Group.

MAJOR OIL CO., 1 PHILLIPS SE NE 11-8N-26W (Bk-54)

Granite porphyry...... Microcline perthite (61%), quartz (27%), hornblende (5%), plagioclase (4%), iron ore (2%), biotite (tr.), pyroxene (tr.), calcite (tr.), feldspar alterations (tr.), zircon (tr.), apatite (tr.). Large ill-defined phenocrysts of microcline perthite are set in a groundmass of microcline perthite, quartz, and plagioclase in a granular irregularly grained relationship; perthite is both string and patch type; two varieties of hornblende are noted, one forming cores is almost colorless and grades at a mottled margin to a normal green variety; pyroxene relicts associated with hornblende; apatite and zircon are large and numerous. Grain size: to 4 mm. Texture: porphyritic and hypidiomorphic granular.

4370-4380'
Cuttings
Bk-54-1

This well penetrated rock of the Wichita Granite Group.

EARL BARNES, 1 GAMBLE C NW NE 7-8N-26W (Bk-57)

Quartz diorite...... Plagioclase (calcic andesine) (49.5%), carbonate (16.1%), hornblende (10.2%), iron ore (8.5%), biotite (6.4%), quartz (5.3%), sphene-leucoxene (1.4%), chlorite-biotite (1.1%), feldspar alterations (0.8%), pyroxene (0.6%), apatite (tr.). Plagioclase is generally fresh but contains numerous alteration veinlets and patches; common hornblende is abundant and red-brown biotite occurs in well-crystallized, large books; former pyroxene has been replaced almost completely by calcite; hornblende mottles relicts of pyroxene; sphene-leucoxene replaces sphene; iron ore is primary and replacing portions of biotite; chlorite-biotite in poorly crystalline shreds associated with calcite; quartz is an intergranular primary mineral. Grain size: 1.5 mm average. Texture: hypidiomorphic.

2606' ca.
Cuttings
Bk-57-3

Earl Barnes, 1 Gamble (cont.)

Diorite and quartz diorite...... Plagioclase (An_{44}) (57.8%), hornblende (15.8%), biotite (7.9%), quartz (6.8%), pyroxene (6.0%), iron ore (3.7%), calcite (1.2%), apatite (tr.), feldspar alterations (tr.), alteration micas (tr.). Variation in texture and mineralogic percentages is marked. Femic-poor chips contain much intergranular quartz which may be optically oriented over a 5 mm diameter; femic-rich chips contain pyroxene in large crystals, containing schiller structure and associated with hornblende at margins; pyroxene also as smaller rounded discrete crystals; calcic andesine shows some preferred orientation; larger plagioclase crystals are zoned slightly; alteration of plagioclase variable but generally minor. Grain size: 2 mm average.. Texture: xenomorphic to hypidiomorphic.

2880-2900' Cuttings Bk-57-6

Diorite...... Plagioclase (An_{44}) (53.7%), hornblende (10.5%), pyroxene (12.1%), biotite (7.7%), iron ore (5.4%), feldspar alterations (1.7%), quartz (tr.), apatite (tr.), siderite (tr.), sphene-leucoxene (tr.), chlorite (tr.). Mineral percentages vary considerably in chips; rock is basically similar to the previous sample; larger plagioclase phenocrysts have mottled zoning and altered cores; quartz is an irregular intergranular mineral; pyroxene is partly associated and mottled with hornblende; biotite is deep red brown; some hornblende is actinolitic but most is a common variety; carbonate veinlet appears to be siderite; chloritic micas irregularly replace cores of some pyroxene. Grain size: 1 mm average, 3 mm maximum. Texture: hypidiomorphic, slightly porphyritic.

3130-3150' Cuttings Bk-57-10

Diorite...... Plagioclase (54.0%), pyroxene (16.4%), hornblende (14.2%), biotite (4.7%), iron ore (3.8%), feldspar alterations (2.8%), chlorite (2.2%), calcite (0.6%), quartz (0.3%), sphene (0.3%), apatite (tr.), rutile (tr.). Plagioclase is extensively altered in some chips, fresh in others; pyroxene is replaced locally by semiopaque masses of mica and sphene-leucoxene; calcite also replaces pyroxene; common hornblende locally associated with mottled primary red-brown biotite which also occurs as well-crystallized books; quartz is a minor intergranular mineral; iron ore occurs as irregular intergrowths and inclusion in femic minerals; secondary uralitic hornblende also present. Grain size: 1.5 mm average. Texture: hypidiomorphic.

3380-3400' Cuttings Bk-57-15

This well penetrated the maximum thickness of the dioritic phase of the Raggedy Mountain Gabbro Group. A biotite separate from 3,230 to 3,400 feet was dated by the K/Ar method to be 500 m.y. The four samples described were selected from fifteen thin sections and are considered representative. The general trend is toward less quartz in the lower part of the sequence. The pyroxenes are considerably fresher in the lower section, the upper part being extensively replaced by calcite. There is no distinct differentiation trend except as shown by the quartz, and the An content of the plagioclase ranges only between 43 and 47 percent. It is a remarkably uniform rock, with slight textural and mineralogic variation. The rock is fine to medium grained, finer than normal gabbro of the Raggedy Mountain Group but texturally like the other diorites of southwestern Beckham County.

BRYAN COUNTY

R. W. RIDDLES, 2 McCOY SW NE NE 27-5S-10E (Br-1)

Andesine diabase...... Andesine, pyroxene, chlorite, iron ore, biotite, amphibole, feldspar alterations, apatite. Andesine is fresh to clouded and veined with alterations; pyroxene is pale brown and altering to chlorite and uralitic hornblende; magnetite granules altering to hematite at margins; biotite as primary red-brown variety and secondary fibrous green replacements. Grain size: 0.6 mm average. Texture: subophitic to intersertal.

Slush pit Cuttings Br-1-1

The cuttings from this well are slush-pit samples from an unknown depth. The rock is interpreted as a younger intrusive dike of the Eastern Arbuckle Province.

PHILLIPS PETR. CO., 1 MATOY SW NW 24-5S-11E *(Br-2)

Diorite...... Plagioclase (50%), hornblende (34%), biotite (8%), iron ore (6%), sericite (2%), calcite (tr.), sphene (tr.), epidote (tr.), apatite (tr.), zircon (tr.). Andesine (An_{41}) highly sericitized locally; hornblende is well formed in large subhedral crystals containing alterations to fibrous biotite; primary biotite is olive green and associated with hornblende; epidote in small secondary masses. Photomicrograph, pl. XVI-5. Grain size: to 1.5 mm. Texture: hypidiomorphic.

835-845' Cuttings Br-2-1

Granite porphyry...... Microcline (43.9%), quartz (29.1%), plagioclase (24.2%), biotite (2.5%), epidote (0.3%), sphene (tr.), feldspar alterations (tr.), chlorite (tr.), hornblende (tr.), muscovite (tr.), iron ore (tr.), zircon (tr.), apatite (tr.). Large fresh microcline crystals are subhedral and contain poikilitically enclosed quartz, plagioclase, and biotite; plagioclase twins are bent locally and larger crystals contain well-formed epidote and muscovite as crystalloblastic alterations; quartz is strained and irregular in form; biotite is olive green and partly altered to chlorite; minor brown hornblende is associated with biotite; textural variations in grain size and shape are marked. Grain size: to 1 cm. Texture: porphyritic and hypidiomorphic granular.

963' Core Br-2-29

Hornblende-rich diorite...... Hornblende (55%), biotite (21%), feldspar alterations (8%), plagioclase (12%), iron ore (3%), quartz (1%), calcite (tr.), chlorite (tr.), sphene-leucoxene (tr.), apatite (tr.), zircon (tr.). Large hornblende crystals contain poikilitically enclosed apatite, biotite, and iron ore; plagioclase is highly altered to sericite-clay-zeolite aggregates in a mottled pattern; hornblende is blue green; biotite is reddish brown and contains minor interlayered chlorite with attendant sphene-leucoxene; apatite and zircon as long slender prisms. Grain size: to 2 mm. Texture: hypidiomorphic.

1001' Core Br-2-11

Amphibole diorite...... Hornblende (59%), plagioclase (22%), biotite (13%), iron ore (3%), sericite (tr.), sphene (tr.), epidote (tr.), apatite (tr.), rutile? (tr.). Exceptionally high mafic content probably due to local segregation; some biotite and plagioclase crystals are bent; andesine contains some sericite; tremolitic hornblende replaces portions of original common hornblende; apatite exceptionally large and well formed; rutile(?) associated with biotite. Grain size: 2 mm. Texture; hypidiomorphic.

1010-1030' Cuttings Br-2-2

Diorite...... Plagioclase (61%), hornblende (26%), biotite (8%), iron ore (4%), feldspar alteration (tr.), calcite (tr.), sphene (tr.), epidote (tr.), apatite (tr.), zircon (tr.). Andesine altering to minor sericite and clay; sphene in discrete crystals and as an alteration around titaniferous magnetite; epidote associated with hornblende and as

1200-1220' Cuttings Br-2-3

Phillips Petr. Co., 1 Matoy (cont.)

as inclusionlike crystals in andesine, perhaps as an alteration. Grain size: 1.5 mm. Texture: hypidiomorphic.

Mylonite...... Rock paste, quartz, micas, feldspar, epidote, hornblende, calcite; iron ore. Rock paste of submicroscopic minerals is lineated with color bands of brown, green, and tan; the original rock appears to be a diorite and relict "eyes" of the parent material remain; epidote developed in rock paste; chertose quartz in lineations parallel to mylonitic trends. Grain size: variable. Texture: cataclastic.

1550-1570'
Cuttings
Br-2-4

Mylonized granite...... Microcline, quartz, plagioclase, rock paste, micas, sphene, iron ore, epidote, calcite. Straining and lineation present in every chip; megascopic examination suggests smearing of mineral boundaries; chertose quartz outlines linear movement; mica is largely biotite, reduced to shreds and possibly altered to chlorite. Grain size: to 4 mm. Texture: cataclastic.

1590-1600'
Cuttings
Br-2-5

Mylonite...... Rock paste, quartz, calcite, micas, feldspar, iron ore, sphene-leucoxene, epidote. Very small relict "eyes" suggest this was originally a granite; chertose quartz bands developed parallel to the lineation; calcite as finely disseminated specks and blebs; micas are sericite, biotite, and chlorite, all in very small shreds; iron ore is sparse. Grain size: variable. Texture: cataclastic.

1840-1850'
Cuttings
Br-2-6

Diorite...... Plagioclase (57%), hornblende (21%), biotite (8%), iron ore (6%), feldspar alterations (4%), chlorite (2%), epidote (1%), sphene (1%), calcite (tr.), apatite (tr.), zircon (tr.). Alteration of plagioclase is advanced, composition undetermined; sphene is both primary and secondary, occurring with titaniferous magnetite; hornblende as deep-green subhedral crystals altering to chlorite; epidote as vein mineral. Grain size: 2 mm. Texture: hypidiomorphic.

1870-1880'
Cuttings
Br-2-7

Diorite...... Plagioclase (49%), hornblende (30%), biotite (11%), feldspar alterations (5%), iron ore (3%), epidote (1%), sphene (tr.), apatite (tr.), zircon (tr.). Sodic andesine altering to major sericite and minor clay minerals; two varieties of epidote present with a clinozoisite type as a late vein mineral; zircon exceptionally long and slender; biotite associated with hornblende. Grain size: 1.5 mm. Texture: hypidiomorphic.

1990-2000'
Cuttings
Br-2-8

Diabase...... Plagioclase, pyroxene, feldspar alterations, biotite, iron ore, chlorite, calcite, apatite. Grain size and texture are variable and suggest chilling; finer chips are porphyritic; plagioclase contains zeolitic alterations; pigeonitic augite altering to chlorite and biotite; apatite in exceptionally fine needles. Grain size: variable. Texture: intersertal to porphyritic.

2000-2010'
Cuttings
Br-2-9

Quartz diorite...... Plagioclase (39%), hornblende (33%), biotite (9%), feldspar alterations (9%), quartz (6%), sphene (2%), epidote (1%), iron ore (tr.), calcite (tr.), apatite (tr.), zircon (tr.). Euhedral and subhedral laths of hornblende in a matrix of xenomorphic to hypidiomorphic quartz and plagioclase; iron ore unusually sparse; andesine highly altered in some chips; sphene common as granules; biotite is olive green and associated with hornblende. Grain size: 1.5 mm. Texture: hypidiomorphic to xenomorphic and porphyritic.

2290-2300'
Cuttings
Br-2-10

Mylonite...... Quartz, rock paste, plagioclase, chlorite, microcline, iron ore, epidote, pyrite, biotite, sphene-leucoxene. Compositions of chips vary and relicts of both granite and diorite are noted; pyrite occurs in mylonite streaks; relict quartz is strained; sphene-leucoxene as granules along lineation; epidote secondary. Grain size: relicts to 4 mm. Texture: cataclastic.

4880-4890'
Cuttings
Br-2-12

Phillips Petr. Co., 1 Matoy (cont.)

Diabase...... Plagioclase (49%), pyroxene (21%), iron ore (18%), feldspar alterations (4%), chlorite (4%), biotite (3%), calcite (tr.), apatite (tr.). Plagioclase (An_{36}) is andesine, altering to clay-sericite-zeolite masses; pyroxene altering to chlorite and biotite; apatite and acicular inclusions in plagioclase; magnetite altering to hematite. Grain size: 0.4 mm. Texture: ophitic to subophitic.

5630-5640'
Cuttings
Br-2-13

Mylonized granite...... Microcline, plagioclase, quartz, epidote, biotite, chlorite, iron ore, feldspar alterations, apatite, zircon. Cataclastic zones of reconstituted rock constituents cut rock; low birefingent variety of chlorite replaces biotite in part; epidote as discrete crystals and aggregates; sericite after microcline and albite. Grain size: relicts to 4 mm. Texture: cataclastic.

6170-6180'
Cuttings
Br-2-14

Granite...... Microcline, quartz plagioclase, biotite, chlorite, sericite, iron ore, apatite. Small amounts of myrmekitic intergrowth present; epidote common as inclusions in feldspar, as a probable alteration; biotite altering to a pennine-type chlorite with associated epidote; quartz partially strained; sericite associated in part with biotite, well crystallized and possibly crystalloblastic. Grain size: 3 mm+. Texture: hypidiomorphic.

6400-6410'
Cuttings
Br-2-15

Granite...... Microcline (41%), plagioclase (33%), quartz (19%), chlorite (2%), sericite (2%), biotite (1%), epidote (1%), iron ore (tr.), calcite (tr.), sphene (tr.), apatite (tr.), zircon (tr.). A more granular texture than present in previous granites and somewhat finer grained; plagioclase is oligoclase (An_{13}); pennine-type chlorite replaces biotite; epidote in discrete crystals and associated with calcite in veins; sphene as a granular rim around titaniferous magnetite; quartz strained. Grain size: to 3 mm. Texture: hypidiomorphic granular.

6500-6510'
Cuttings
Br-2-17

Granite...... Microcline (42%), plagioclase (33%), quartz (21%), epidote (1%), biotite (1%), sericite (tr.), iron ore (tr.), sphene (tr.), apatite (tr.), zircon (tr.), rutile (tr.). Unusual porphyroblastic sericite associated with epidote, also in veins with sphene; microcline fresh; oligoclase contains some sericite alterations; rock has low percentage of accessory minerals. Grain size: to 5 mm. Texture: hypidiomorphic and incipient crystalloblastic.

7650-7670'
Cuttings
Br-2-18

Granite porphyry......Microcline, quartz, plagioclase, epidote, biotite, sphene, sericite, calcite, iron ore, clay, apatite. Microcline may be perthitic in part; large phenocrysts of microcline present; sericite porphyroblasts sprouted in feldspars with epidote; epidote also as a vein mineral; quartz is large and strained. Grain size: to 6 mm. Texture: hypidiomorphic, porphyritic and incipient crystalloblastic.

8100-8110'
Cuttings
Br-2-19

Quartz diorite...... Plagioclase, hornblende, biotite, sphene, quartz, feldspar alterations, epidote, iron ore, calcite, apatite, zircon. Andesine altered to minor clay and sericite; sphene exceptionally abundant and well crystallized; epidote in large spongy-appearing crystals with biotite; biotite is olive green whereas hornblende is blue green; calcite associated with plagioclase. Grain size: 1 mm. Texture: hypidiomorphic.

8340-8350'
Cuttings
Br-2-20

Quartz-bearing diabase...... Plagioclase, pyroxene, iron ore, biotite, amphibole, quartz, chlorite, sericite, calcite, apatite. Quartz appears primary, contains apatite needles and is never in contact with pyroxene, always having a buffer of amphibole or biotite; labradorite altering to sericite and calcite; magnetite as large anhedral crystals. Grain size: 1 mm. Texture: subophitic.

8590-8600'
Cuttings
Br-2-21

Phillips Petr. Co., 1 Matoy (cont.)

Diabase...... Plagioclase, pyroxene, iddingsite, biotite, chlorite, iron ore, feldspar alterations, apatite. Labradorite laths altering to minor sericite; iddingsite as complete pseudomorphs after olivine; both biotite and chlorite as alterations from pyroxene; some red-brown biotite may be primary; apatite as acicular inclusions. Grain size: 0.5 mm. Texture: subophitic.
9020-9030'
Cuttings
Br-2-23

Granite (porphyry?)...... Microcline, plagioclase, quartz, epidote, biotite, iron ore, calcite, sericite, apatite. Microcline in larger crystals, possibly phenocrysts; large quartz crystals are strained; sericite and epidote are porphyroblastic associates; oligoclase altering to sericite. Grain size: to 3.5 mm. Texture: hypidiomorphic, incipient crystalloblastic, and possibly porphyritic.
10304'
Cuttings
Br-2-24

Granite porphyry...... Microcline, quartz, plagioclase, biotite, chlorite, epidote, sericite, iron ore, sphene, apatite, calcite. Microcline clear, unaltered and well twinned; small amounts of myrmekitic intergrowth present; albite contains minor sericite alterations; sericite associated with biotite in large, possibly crystalloblastic, crystals. Photomicrograph, pl. XVI-1. Grain size: to 2.5 mm. Texture: hypidiomorphic, porphyritic, and incipient crystalloblastic.
11510-11520'
Cuttings
Br-2-26

Schistose quartz diorite...... Plagioclase (54%), biotite (15%), quartz (9%), hornblende (6%), epidote (5%), sericite (4%), iron ore (3%), sphene (2%), chlorite (2%), clay (tr.), apatite (tr.). Biotite aligned in a schistose manner and set in a xenomorphic mosaic of quartz and plagioclase; the rock may be a metadiorite dike or inclusion; andesine (An_{39}) contains minor sericite; chlorite after biotite; epidote as suboriented crystals. Photomicrograph, pl. XVI-6. Grain size: 0.3 mm average. Texture: lepidioblastic.
11170-11180'
Cuttings
Br-2-27

Diabase...... Plagioclase (56%), pyroxene (27%), iron ore (12%), chlorite (3%), biotite (1%), calcite (tr.), amphibole (tr.), sericite (tr.), apatite (tr.). Labradorite clouded by sericite alteration; both clinopyroxene and orthopyroxene present, and both alter to chlorite and uralitic hornblende; some biotite appears primary. Grain size: to 1.2 mm. Texture: subophitic.
12513'
Cuttings
Br-2-28

The Phillips, 1 Matoy is the deepest known penetration of basement rock in the world. The well was drilled in granite, diorite, and diabase of the Eastern Arbuckle Province and is located in the buried core of the Tishomingo anticline. The granite is like that of the outcrop in the Tishomingo-Troy area and is cut by numerous younger dikes and/or sills of diorite and diabase. The well was drilled in hopes of penetrating a low-angle thrust fault and entering strata of Paleozoic age. The diabase and diorite dikes and/or sills may have been emplaced along subparallel planes of weakness that could cause anomalous geophysical data. Extensive mylonization, particularly near the top of the drilled sequence, may be caused by Paleozoic orogeny or by Precambrian tectonism. In any case the tectonic deformation is younger than the diorite (1,190 m.y.) because the diorites are extensively mylonized. The diabases were not noted to be affected by the cataclastic movements. The California Oil Co., 1 Jones (Br-8) in 9-7S-10E is also characterized by strong cataclastic effects. Metamorphism is scarcely noticeable in the granites but is more marked in the lowest diorite (11,170-11,180', Br-2-27), in which a granoblastic and highly schistose character is developed. Oddly, the diabase at the bottom of nearly 12,000 feet of basement rock is lacking in metamorphic effects, suggesting a much younger age for the emplacement of the diabase.

CALIFORNIA OIL CO., 1 JONES NW NW NW 9-7S-10E (Br-8)

Cataclastic granite...... Microcline, plagioclase, quartz, hornblende, biotite, chlorite, feldspar alterations, epidote, iron ore, sphene-leucoxene, calcite, zircon, apatite. Quartz grains are highly strained; feldspar strained to a lesser extent; a pennine-type of chlorite is associated with biotite in wavy and bent crystals; epidote grains are large and pale yellow green, with a mild pleochroism; feldspars are mottled with extensive sericite; the rock is unusually abundant in mafic and alteration minerals. Grain size: 4 mm+. Texture: cataclastic and relict hypidiomorphic.
4560-4590'
Cuttings
Br-8-1

Mylonite...... Rock paste, quartz, chlorite, iron ore. The rock paste and quartz comprise at least 95 percent of the slide; the rock is highly lineated and pulverized and appears in cuttings very similar to a finely laminated pale-green chert; bands of quartz-rich material are highly strained though extremely fine grained; clay-rich bands have a semi-isotropic character; few very small and minor relict eyes remain; chlorite as masses associated in part with iron ore. Photomicrograph, pl. XVI-4. Grain size: relicts to 0.1 mm. Texture: cataclastic.
4790-4800'
Cuttings
Br-8-2

Cataclastic granite...... Microcline, plagioclase, quartz, sphene-leucoxene, biotite, feldspar alterations, chlorite, hornblende, iron ore, epidote, muscovite, apatite, zircon. Quartz and, to a lesser extent, feldspars have undulose extinction; linear slippage planes are filled with sphene-leucoxene, biotite, iron ore and clay minerals; minor myrmekitic intergrowth locally developed; large pseudomorphs of chlorite contain interlayered granular sphene; crystalloblastic muscovite and epidote are present; feldspar alterations are extensive but erratic. Grain size: to 3 mm. Texture: cataclastic, relict hypidiomorphic, and crystalloblastic.
5400-5430'
Cuttings
Br-8-3

Cataclastic granite...... Microcline, plagioclase, quartz, epidote, calcite, feldspar alterations, biotite, hornblende, chlorite. A finer grained granite than above; cataclastic effects are marked as shown in strained quartz and mortar boundaries; no iron ore and few femic minerals are present; some microcline has a perthitic appearance; feldspars are generally fresh. Grain size: to 2 mm+. Texture: cataclastic and relict hypidiomorphic.
6010-6030'
Cuttings
Br-8-4

Cataclastic granite...... Microcline, plagioclase, quartz, calcite, biotite, hornblende, epidote, iron ore, chlorite, feldspar alterations, zircon, apatite. Quartz is highly strained and reconstituted; feldspars have mortar boundaries; feldspars are erratically altered and are associated with intergranular and vein epidote; hornblende and biotite are altered to minor chlorite; calcite replaces feldspar and is common in veins; some microcline has a perthitic appearance. Grain size: 2.5 mm+. Texture: cataclastic and relict hypidiomorphic.
6540-6570'
Cuttings
Br-8-5

Cataclastic granite porphyry...... Microcline, plagioclase, quartz, biotite, hornblende, epidote, feldspar alterations, sphene, iron ore, apatite, calcite, zircon. Highly strained and reconstituted quartz grains are present; feldspar boundaries show well-defined mortar structure; thin quartz veins cut feldspars; epidote is in well-formed crystalloblastic masses; hornblende is deep blue green; large single sphene crystals present; large biotite crystals are altered to chlorite; feldspars are erratically altered, show slippage planes and distorted twinning. Grain size: 3 mm+. Texture: porphyritic, cataclastic, and relict hypidiomorphic.
7040-7060'
Cuttings
Br-8-6

7340-7360'
Cuttings
Br-8-7

Cataclastic granite...... Microcline, plagioclase, quartz, biotite, chlorite, feldspar alterations, epidote, iron ore, sphene, hornblende, apatite, zircon. Mortar structure present between feldspar grains; crystalloblastic epidote developed between and within feldspar grains; straining in quartz is extensive; plagioclase generally more altered than microcline; large microclines show slippage planes; chlorite and associated sphene replace biotite; large discrete sphene crystals present; apatite prisms are large and numerous. Grain size: to 5 mm. Texture: cataclastic and relict hypidiomorphic.

7710-7730'
Cuttings
Br-8-8

Cataclastic granite...... Plagioclase, microcline perthite, quartz, chlorite, feldspar alterations, biotite, hornblende, epidote, iron ore, sphene-leucoxene, zircon, apatite. Highly strained and reconstituted quartz grains have conspicuously undulose extinction; mortar boundaries are common; chlorite and associated sphene replace biotite; feldspars are highly altered and contain crystalloblastic epidote; minor myrmekitic intergrowth locally developed. Grain size: to 3.5 mm. Texture: cataclastic and relict hypidiomorphic.

7910-7920'
Cuttings
Br-8-9

Diabase...... Plagioclase, tremolitic amphibole, feldspar alterations, pyroxene, iron ore, chlorite, biotite. Plagioclase laths are trachytically to subtrachytically aligned and are highly altered to clay-sericite-zeolite masses and veins; pale-brown pyroxene is associated with iron ore and altered to tremolitic amphibole; small amounts of alteration biotite and chlorite are present; an absence of cataclastic features is noted. Grain size: to 1.2 mm. Texture: subtrachytic and subophitic.

This well, penetrating rocks of the Eastern Arbuckle Province, is located on a fault block that is the southeastward extension of the Tishomingo anticline. The universal cataclastic effects shown by the granite are a striking feature, apparent in the cuttings even megascopically. The texture of the diabase found near the base of the well is in marked contrast to those of the overlying rocks, for, although showing alteration effects, it has no cataclastic alteration of any sort.

SINCLAIR OIL & GAS CO., 1 EVERETT UNIT NE NW NW 1-7S-9E (Br-9)

5690-5720'
Cuttings
Br-9-1

Altered granite...... Microcline, plagioclase, quartz, epidote, chlorite, feldspar alterations, sphene, biotite?, apatite, hematite, calcite. This granite has been extensively replaced by aggregates and discrete crystals of epidote; badly altered pale-green biotite(?) is associated with chlorite; several cutting chips show severe crushing and reorganization; hematite is the only iron ore present and is found as disseminated flakes in feldspars and as thin veinlets; microcline is partially perthitic. Grain size: 2.5 mm+. Texture: hypidiomorphic and cataclastic.

6050-6080'
Cuttings
Br-9-2

Granite...... Microcline, plagioclase, quartz, biotite, hornblende, epidote, chlorite, iron ore, sphene, feldspar alterations, zircon, apatite. Quartz shows undulose extinction and some mortar boundaries; feldspars contain sericite flakes, are generally turbid, and have faint zoning; epidote is developed as sparse crystals in feldspars; hornblende and biotite are altered to chlorite in part; microcline is partially perthitic; quartz appears to be locally concentrated. Grain size: 6 mm+. Texture: hypidiomorphic.

6430-6450'
Cuttings
Br-9-3

Feldspathic (Reagan) orthoquartzite...... Quartz, microcline, calcite, clay-sericite, plagioclase, iron ore, zircon. This orthoquartzite is very similar to an unusual type of Reagan Sandstone immediately overlying the basement rock in this well. If not caused by sample caving, it represents a fault slice of Cambrian Reagan Orthoquartzite within the basement complex. Grain size: to 1 mm. Texture: clastic.

6670-6680'
Cuttings
Br-9-5

Granite...... Microcline, plagioclase, quartz, chlorite, epidote, sphene, biotite, sericite-muscovite, iron ore, calcite, apatite, zircon. Quartz is generally strained; microcline is fresher than plagioclase; plagioclase contains a fibrous mat of sericite or may have discrete crystals of muscovite and epidote; biotite is partly replaced by chlorite; sphene is in wedge-shaped crystals and irregular masses. Grain size: 5 mm+. Texture: hypidiomorphic and incipient crystalloblastic.

7430-7440'
Cuttings
Br-9-6

Diabase...... Plagioclase (48%), augite (36%), iron ore, chlorite, sphene-leucoxene, biotite, calcite, feldspar alterations, apatite. An amazingly fresh diabase considering the character of the older granites; intermediate labradorite laths are essentially water clear with only minor thin veinlets of alteration material; augite is also fresh but is altered to chlorite locally with secondary biotite in association; a fibrous mineral, possibly a variety of chlorite, replaces a mass that may have been an olivine crystal; sphene-leucoxene is found as small granules associated with chlorite and around titaniferous magnetite. Grain size: to 0.6 mm. Texture: subophitic.

7470-7480'
Cuttings
Br-9-7

Granite...... Microcline, plagioclase, quartz, biotite, epidote, chlorite, sphene, hornblende, feldspar alterations, zircon, apatite. Cataclastic effects shown in strained quartz and bent plagioclase twins; plagioclase is particularly turbid with sericite flakes and other alterations, while microcline has larger less numerous epidote crystals as inclusions; olive-green biotite altered to chlorite with attendant granular sphene, sphene also as well-formed wedge-shaped crystals. Grain size: 5 mm+. Texture: hypidiomorphic and cataclastic.

7720-7730'
Cuttings
Br-9-8

Granite...... Microcline, plagioclase, quartz, biotite, hornblende, chlorite, epidote, sphene, feldspar alterations, calcite, apatite, zircon. Linear cracks, some with secondary mineralization and undulose quartz, indicate cataclastic alteration; sphene is found as well-formed crystals and as granular masses associated with chlorite and as rims around titaniferous magnetite; plagioclase is more turbid with alterations than microcline; microcline is faintly zoned; biotite and hornblende are olive green while chlorite is a brighter blue green; epidote is well developed as inclusions in feldspars; apatite is locally abundant. Grain size: 5.5 mm+. Texture: hypidiomorphic and cataclastic.

The basement rocks in this well are overlain by an exceptionally thick sequence of Reagan Sandstone. The basement rock is typical of the Eastern Arbuckle Province. Samples from 6,425 to 6,530 feet contained abundant Reagan Sandstone chips of the type directly overlying the basement complex. This may represent a fault slice of Paleozoic rocks within the basement or it may be due to sample contamination.

The well was drilled along the same fault zones as were the California, 1 Jones and the Honeymon, 1 Townsend, yet the rocks show only slight cataclastic deformation.

HONEYMON DRILLING CO., 1 TOWNSEND   SE SE NW 30-5S-8E   (Br-10)

Granite...... Microcline perthite, plagioclase, quartz, chlorite, iron ore, epidote, biotite, feldspar alterations, sphene, hornblende, calcite, apatite. Microcline perthite is fresher in appearance than the plagioclase; straining of quartz is marked; several chips show cataclastic linears and one chip is reduced to a microbreccia; chlorite replaces biotite extensively and is associated with finely granular sphene; epidote is intergranular, either as large crystals or as granular masses; titaniferous magnetite is surrounded by sphene. Grain size: 3 mm+. Texture: hypidiomorphic and cataclastic.

740-750'
Cuttings
Br-10-1

Cataclastic granite...... Microcline (42%), plagioclase (36%), quartz (16%), biotite-chlorite (1.4%), epidote (0.8%), muscovite, iron ore, sphene, feldspar alterations, calcite. Strong cataclastic deformation has reduced grain size, in part to a microbreccia; numerous cataclastic linears are present; muscovite is developed as discrete flakes in feldspars and as intergranular books; epidote, a common variety with minor clinozoisite, is found as intergranular crystals and granular masses within the feldspars; chlorite and associated sphene replace biotite completely; microcline is partly perthitic; plagioclase crystals (An_{10}) are faintly zoned. Grain size: 3 mm+. Texture: cataclastic and relict hypidiomorphic.

1100-1130'
Cuttings
Br-10-2

Granite...... Microcline, quartz, plagioclase, chlorite, epidote, muscovite, iron ore, sphene, feldspar alterations, calcite, biotite. Quartz is highly undulose, and cataclastic linears are common; relicts of biotite remain in the chlorite and associated sphene; muscovite is associated with chlorite and epidote and appears to be crystalloblastic; microcline is partly perthitic; plagioclase contains more alterations than microcline. Grain size: 4 mm+. Texture: cataclastic and hypidiomorphic.

1433-1463'
Cuttings
Br-10-3

Granite...... Plagioclase, microcline, quartz, epidote, muscovite, chlorite, iron ore, feldspar alterations, sphene, biotite, apatite. Strained quartz and bent plagioclase twins demonstrate cataclastic alteration but it is much less marked than in previous samples; muscovite is well developed as crystalloblastic books enclosed in plagioclase and is also present in association with chlorite and epidote; plagioclase is turbid with alterations and locally contains blebs of water-clear microcline; small amounts of secondary biotite are present. Grain size: 3 mm+. Texture: hypidiomorphic and incipient cataclastic.

2330-2340'
Cuttings
Br-10-4

Diabase...... Plagioclase, pyroxene, tremolitic amphibole, chlorite, iron ore, feldspar alterations, prehnite, calcite, apatite. Labradorite laths are clouded with alteration and replacement products, much of which is introduced chlorite; pale-brown pyroxene is altering to a pale-green or nearly colorless tremolitic amphibole; prehnite is present as a vein mineral; apatite is irregularly distributed; finer grained chips are more highly altered than the coarser. Grain size: to 0.7 mm. Texture: subophitic.

2590-2600'
Cuttings
Br-10-5

Cataclastic granite...... Microcline, quartz, plagioclase, rock paste, iron ore, epidote, muscovite, chlorite, feldspar alterations. A highly crushed granite with some chips reduced to a microbreccia; in the microbreccia mineral fragments are suspended in a rock paste of pulverized minerals; in the less brecciated portions numerous slippage planes are noted; feldspars are generally turbid with alterations; apatite and zircon are absent. Grain size: relicts to 2 mm+. Texture: cataclastic.

2730-2740'
Cuttings
Br-10-6

Honeymon Drilling Co., 1 Townsend (cont.)

Cataclastic granite...... Plagioclase, quartz, microcline, rock paste, epidote, feldspar alterations, calcite, iron ore, chlorite, sphene-leucoxene, zircon, apatite. Few normal mineral contacts remain, as most are in contact along slippage planes; rock paste is found along most severe dislocation planes; epidote is granulated along cataclastic planes indicating a younger age for the dislocations; chlorite, epidote, and sphene are found along slippage planes; feldspars contain unoriented sericite flakes. Grain size: relicts to 1.5 mm. Texture: cataclastic.

3060-3070'
Cuttings
Br-10-7

Granite...... Microcline, quartz, plagioclase, epidote, iron ore, chlorite, muscovite, feldspar alterations, sphene, biotite, apatite. Plagioclase twins are bent and quartz is strained; one chip is a microbreccia, but cataclastic effects are less marked than in the previous sample; relicts of olive-green biotite are found in chlorite and associated sphene; feldspar alterations cloud feldspars; discrete muscovite flakes are found within feldspars and as an intergranular mineral; microcline is partly a string perthite. Grain size: 4 mm+. Texture: hypidiomorphic and cataclastic.

3400-3410'
Cuttings
Br-10-8

Granite...... Plagioclase, microcline, quartz, chlorite, epidote, muscovite, feldspar alterations, sphene, iron ore, hornblende, apatite. One chip is a microbreccia and others show slight cataclastic effects; a secondary variety of hornblende is associated with sphene and chlorite; feldspars are clouded with alterations and contain crystalloblastic epidote and muscovite; epidote-chlorite-sphene aggregates are associated in linear trend, intergranular to quartz and feldspar. Grain size: 3 mm+. Texture: hypidiomorphic and cataclastic.

3560-3570'
Cuttings
Br-10-9

Cataclastic granite...... Microcline, plagioclase, quartz, chlorite, muscovite, feldspar alterations, epidote, iron ore, rock paste, sphene-leucoxene, apatite. Bent and brecciated mineral fragments suspended in a paste of pulverized rock fragments are common in all chips; chlorite is pale green and mildly pleochroic with anomalous interference colors; portions of the microcline are perthitic; minerals appear to be unequally distributed as some chips are composed almost entirely of quartz and others of feldspar; muscovite is associated with chlorite and epidoté. Grain size: 5 mm+. Texture: cataclastic and relict hypidiomorphic.

3900-3910'
Cuttings
Br-10-10

Granite microbreccia...... Microcline, quartz, plagioclase, rock paste, calcite, chlorite, sphene, iron ore, epidote, feldspar alterations, zircon. Each chip has been brecciated and the fragments are set in a matrix of rock paste; calcite veinlets fill linears and irregularly replace feldspars; brecciation affects all minerals except calcite; chlorite is reduced to a mass of unoriented shreds associated with sphene-leucoxene; one small zircon is noted. Grain size: relicts to 3 mm. Texture: cataclastic and relict hypidiomorphic.

4220-4230'
Cuttings
Br-10-11

This well, an important source of basement-rock information on the south side of the Tishomingo anticline, was drilled from rocks of Cretaceous age into rocks of the Eastern Arbuckle Province. At a depth of 4,240 feet the well penetrated a thrust fault and drilled into Ordovician rocks of the Arbuckle Group. This demonstrates that the fault plane bounding the south side of the Tishomingo anticline dips generally north. The brecciation of the granites is unique, for, even though cataclastic effects are characteristic of this province, they are generally not of this type. The well also contained very thick and numerous diabase dikes and/or sills which accounted for about 28 percent of the total footage drilled in the basement rock.

CARTER COUNTY

JONES OIL CO., 3 WALLACE-REED NE NE NW 6-5S-1W (Cr-1)

Rhyolite porphyry...... Groundmass (81%), plagioclase phenocrysts (8%), quartz phenocrysts (6%), potash feldspar phenocrysts (4%), iron ore phenocrysts (1%), chlorite, clay-sericite, leucoxene, calcite, apatite. Highly spherulitic groundmass with local delicate micrographic intergrowth developed; quartz phenocrysts are small and surrounded by radial spherulites; feldspars highly colored with hematite dust and altered to clay-sericite and associated calcite; leucoxene and hematite replace titaniferous iron ore granules; chlorite locally abundant but is generally finely disseminated. Grain size: phenocrysts to 2 mm. Texture: spherulitic and porphyritic.

12650-12660'
Cuttings
Cr-1-1

This well gives important control on the character of the basement complex in an area where little is known. The rock is the most southeasterly penetration of the Carlton Rhyolite Group.

COMANCHE COUNTY

STANOLIND OIL & GAS CO., 1 PERDASOFPY SE NW SW 11-4N-12W (Cm-1)

Perlitic rhyolite porphyry...... Phenocrysts: feldspar (4%), leucoxene (1%); groundmass (95%): quartz, chlorite, iron ore, calcite, feldspar alterations, apatite. Both plagioclase and perthite phenocrysts present but alteration and hematite dust inclusions make modal differentiation difficult; delicate perlitic cracks outlined with chlorite; fluidial banding pronounced around phenocrysts; chlorite and quartz associated in amygdule fillings; titaniferous iron ore altered to leucoxene and contains associated apatite; banding outlined with iron-rich trends. Grain size: phenocrysts to 1.5 mm. Texture: porphyritic and perlitic.

5590-5600'
Cuttings
Cm-1-1

Welded tuff...... Phenocrysts: feldspar (5%), quartz (2%), leucoxene (1%); groundmass (92%): chlorite, calcite, iron ore, feldspar alterations, apatite, zircon. Distorted and flattened devitrified shards in groundmass are squeezed and buckled around phenocrysts of perthite, plagioclase, and quartz; plagioclase almost euhedral and slightly zoned at the outer margin; quartz and perthite phenocrysts are embayed; chloritic masses controlled by distorted shards; hematite content locally high, with leucoxene and magnetite as minor granules; calcite as vein mineral; crystal size varies from band to band. Grain size: phenocrysts to 1.4 mm. Texture: porphyritic and eutaxitic.

5640-5650'
Cuttings
Cm-1-2

Welded tuff...... Phenocrysts: perthite (14%), quartz (3%), iron ore (1%), plagioclase (1%); groundmass (81%): sphene-leucoxene, chlorite, feldspar alterations, apatite, zircon. Wormy and embayed perthite phenocrysts present with smaller subordinate quartz; groundmass composed of well-crystallized, detrital-appearing quartz and feldspars with slight distortions around phenocrysts; hematite content in groundmass is high and serves to outline structure; vague perlite cracks filled with iron ore surround some quartz phenocrysts but are possibly pseudo-perlites; the rock appears to be a "sand flow" with much more crystalline material than was noted in the previous sample. Grain size: phenocrysts to 3 mm. Texture: porphyritic and eutaxitic.

6380-6390'
Cuttings
Cm-1-3

Perlitic rhyolite porphyry...... Phenocrysts: perthite (11%), iron ore (1%); groundmass (88%): quartz, sphene-leucoxene, chlorite, biotite, plagioclase, calcite, feldspar alteration, zircon, apatite. Rounded and wormy phenocrysts of perthite are set in a delicately banded devitrified glass containing perlite cracks; devitrified masses are very delicately branching, spherulitic material in optic units ±0.4 mm in diameter; these units appear to be quartz-feldspar intergrowth and are interspersed with xenomorphic, structureless minerals; banding caused by iron coloration and crystallite "trails." Photomicrograph, pl. VIII-4. Grain size: phenocrysts to 1.5 mm. Texture: porphyritic and perlitic.

7930-7940'
Cuttings
Cm-1-4

Rhyolitic tuff...... Lithic detritus, feldspar, clay-dust cement, chlorite, quartz, leucoxene, iron ore, zircon. Very finely layered clastic rock with abrupt variation in grain size in different layers; some layers are only 0.2 mm wide; cementing agent is clay-dust material very high in chlorite; sphene replaces portions of feldspar and is in well-crystallized masses; much sphene also in granular masses with a high leucoxene content, probably after titaniferous iron ore; sorting and roundness erratic; mineral variability marked; the extremely fine layering suggests a water-laid origin. Grain size: to 0.2 mm. Texture: clastic.

8000-8010'
Cuttings
Cm-1-5

Stanolind Oil & Gas Co., 1 Perdasofpy (cont.)

Micrographic granite porphyry...... Micrographic intergrowth (65%), perthite (22%), quartz (3%), chlorite (4%), plagioclase (2%), iron ore (2%), sphene (1%), feldspar alterations (tr.), amphibole (tr.), pyroxene (tr.), calcite (tr.), apatite (tr.), zircon (tr.). Very delicate micrographic intergrowth is radial to subradial around quartz and perthite phenocrysts; rare perthite phenocrysts have a plagioclase core and are zoned at the outer margins; perthite generally has rounded form and may contain more than one optic unit; pyroxene and amphibole present as small relicts enclosed in chlorite and biotite; chlorite masses associated with apatite, magnetite, and sphene granules; hematite dust common through feldspars; sericite as an erratic alteration of feldspars. Photomicrograph, pl. XI-5. Grain size: phenocrysts 2 mm+. Texture: micrographic and porphyritic.

8340-8350'
Cuttings
Cm-1-6

Chilled granite porphyry...... Phenocrysts: perthite (11%), quartz (5%), chlorite-biotite (2%), iron ore (1%); groundmass (81%): calcite (tr.), amphibole (tr.), feldspar alterations (tr.), plagioclase (tr.), zircon (tr.), apatite (tr.). Delicate, feathery spherulites are radial around phenocrysts of perthite and quartz; phenocrysts are rounded and embayed; perthite crystals are zoned slightly at outer margins and locally composed of more than one optic unit; interspherulite material is felsophyric quartz and feldspar containing abundant chlorite and biotite; rods of mafic minerals are present in the spherulites and appear to be chlorite with sphene; relicts of amphibole present in larger chlorite masses associated with apatite, zircon, and minor sphene; iron-stained rim of sphene present around titaniferous magnetite. Grain size: phenocrysts to 2.5 mm+. Texture: porphyritic, spherulitic, and felsophyric.

8610-8620'
Cuttings
Cm-1-7

Spilite and basalt...... Plagioclase, chlorite, sphene, pyroxene, feldspar alterations, prehnite, calcite. Two distinct rock types, identical in grain size but differing in mineralogy; the spilite is extremely high in granular sphene and contains amygdules of chlorite, calcite, and prehnite; all pyroxene is altered to chlorite, magnetite to hematite and granular sphene; sphene and chlorite invade albite; albite amygdule lined with chlorite is the same composition as the albite in the main rock; chlorite is finely fibrous; the basalt contains pyroxene with ophitically enclosed labradorite laths; patches of chlorite alternate with areas of chlorite; sphene content is lower than in the spilite but it is still abundant; larger labradorite laths slightly zoned; magnetite is mostly unaltered. Grain size: 0.3 mm average. Texture: ophitic to relict ophitic.

8730-8740'
Cuttings
Cm-1-9

Spilite and basalt...... Plagioclase, pyroxene, chlorite, feldspar alterations, iron ore, sphene-leucoxene, prehnite, apatite. Only one spilite chip noted and it is similar to that in the previous sample (Cm-1-9); the basalt contains patches of ophitic pyroxene with enclosed labradorite laths; chloritic masses surround these relict pyroxenes; labradorite highly altered to zeolitic and claylike minerals; sphene relatively minor but iron ore is abundant; vein prehnite associated with chlorite. Grain size: 0.4 mm average. Texture: relict ophitic to ophitic.

8960-8970'
Cuttings
Cm-1-10

Spilite and basalt...... Plagioclase, chlorite, sphene, chalcedony, iron ore, pyroxene, epidote, prehnite, calcite. Spilitic chips are more highly altered and slightly finer grained than basalt; relicts of pyroxene present in spilite chips; spilite in part strongly altered, containing chalcedony, calcite, chlorite, epidote, and prehnite in amygdules; sphene abundant; plagioclase partly prehnitized; one spilite chip shows mass replacement of unoriented plagioclase laths by albite, optically continuous over a substantial area. Grain size: to 0.7 mm. Texture: ophitic.

9040-9050'
Cuttings
Cm-1-11

Stanolind Oil & Gas Co., 1 Perdasofpy (cont.)

Spilite...... Plagioclase, chlorite, pyroxene, iron ore, sphene, calcite, feldspar alterations, apatite. Large chloritic masses fill amygdules; patches of relict pyroxene enclosed in chlorite; two chips are ultra fine grained with spherulitic chlorite amygdules in a cryptocrystalline, subisotropic groundmass containing tiny plagioclase laths; some pyroxenes are phenocrystlike in form; sphene content is lower than in previously described samples. Grain size: 0.3 mm average. Texture: ophitic.

9220-9230'
Cuttings
Cm-1-12

Spilite and basalt...... Plagioclase (B 49%, S 44%), pyroxene (B 22%, S 25%), iron ore (B 11%, S 9%), chlorite (B 6%, S 5%), sphene (B 6%, S 11%), amphibole (B 4%, S --), feldspar alterations (B 2%, S 5%), calcite (tr.). The percentages preceded by a B are for basalt, those preceded by an S are for spilite; the comparison is very close and except for secondary minerals, suggests strongly a common origin; the basalt is slightly coarser and has a suggestion of porphyritic texture; a fibrous amphibole, possibly actinolite, is present in the basalt as a secondary mineral; alteration of magnetite to hematite is extensive, particularly in the spilite. Photomicrograph, pl. XII-1. Grain size: 0.15 mm. Texture: ophitic.

9320-9330'
Cuttings
Cm-1-13

Spilite and basalt...... Plagioclase, pyroxene, chlorite, iron ore, sphene, feldspar alterations. Basalt is fresher than the spilite and contains less chloritic alterations and amygdules; spilites contain chlorite and associated sphene, suggesting an originally titaniferous pyroxene; plagioclase is locally altered; labradorite in basalt is distinctly twinned while the albite in the spilite is poorly twinned. Grain size: 0.2 mm average. Texture: ophitic to relict ophitic.

9330-9340'
Cuttings
Cm-1-14

Silt and argillite...... Chlorite, clay, feldspar, quartz, sphene, iron ore, calcite, prehnite, zircon. Great range in grain size caused by extremely fine layering; the finest grained chips are high in clay and chloritic micas, the clay shows no optic character; one chip has a spotted appearance, apparently caused by incipient recrystallization; a vein of albite cuts a silty chip; calcite replaces irregularly; prehnite as a thin vein; sphene-leucoxene causes semiopaque spotted appearance; some cement is chertose quartz; zircon is detrital. Grain size: 0.2 mm to submicroscopic. Texture: clastic.

9430-9440'
Cuttings
Cm-1-15

Graywacke...... Clay-quartz-chlorite-sphene matrix (46%), lithic detritus (25%), feldspar (19%), quartz (7%), iron ore (2%), prehnite (1%). Diverse rock and mineral fragments set in a heterogeneous matrix of clay-quartz-chlorite-sphene; quartz and feldspars appear to be of volcanic origin; perthite dominates the feldspars but plagioclase and microcline are present; lithic detritus is mainly basaltic but whole and broken spherulites occur with chert and felsophyric fragments; sorting and roundness poor; prehnite is detrital. Grain size: to 2.3 mm. Texture: clastic.

9500-9510'
Cuttings
Cm-1-16

Altered palagonite tuff...... Chlorite, zeolites, lithic detritus, altered palagonite, prehnite, plagioclase, feldspar alterations, quartz. Altered palagonite with undulatory extinction alternates with areas of extremely fine-grained lithic detritus of basaltic origin high in iron; chlorite fills amygdules in altered palagonite in spherulite forms; a chabazite-like zeolite as an amygdule filling with prehnite; altered palagonite is golden brown to olive green and has a glassy appearance; some sphene associated with chlorite; plagioclase as sericitized detritus. Photomicrograph, pl. XII-3. Grain size: to 1.8 mm. Texture: vitroclastic and amygdaloidal.

9560-9570'
Cuttings
Cm-1-17

Stanolind Oil & Gas Co., 1 Perdasotpy (cont.)

9620-9630'
Cuttings
Cm-1-18

Altered palagonite tuff...... Chlorite, lithic detritus, altered palagonite, zeolites, prehnite, plagioclase, chalcedony, calcite, feldspar alterations. Mineralization erratic; some chips contain abundant prehnite, others contain none; more than one zeolite is present as an amygdule filling and as an intergranular material; chlorite in amygdules and groundmass; plagioclase as coarse detritus and later intergranular mineral; one fragment of ophitic pyroxene with enclosed plagioclase laths is present as lithic detritus. Grain size: to 2 mm. Texture: vitroclastic and amygdaloidal.

9650-9660'
Cuttings
Cm-1-19

Altered palagonite tuff...... Lithic detritus, chlorite, chalcedony, calcite, altered palagonite, iron ore, sphene, zeolites, prehnite. Altered palagonite less common than in previous samples; extremely fine-grained lithic detritus more common, whereas zeolites and prehnite are sparse; chalcedony and chlorite abundant as amygdule fillings; sericitized plagioclase laths are large but sparse; granular sphene associated with chlorite. Grain size: to 2.7 mm. Texture: amygdaloidal and vitroclastic.

This is perhaps the most important basement-rock well in southern Oklahoma. The sequence of rhyolites is almost 2,600 feet thick, the rhyolites being texturally diverse yet mineralogically similar. The rhyolite samples described include representative as well as unusual types. The granite sill between the Carlton Rhyolite Group and the Navajoe Mountain Basalt-Spilite Group is markedly chilled at the margins, indicating a younger age. In textural and mineralogical character it is typical of the Wichita Granite Group. The basalt-spilite sequence is more than 1,000 feet thick. It consists chiefly of interlayered basalt and spilite flows with minor sedimentary material. It is impossible to distinguish basalt from spilite in chips without thin-section study. The altered palagonite tuff at the base of the penetrated sequence in this well is the only example of basic tuffs yet found in the Navajoe Mountain Basalt-Spilite Group.

SINCLAIR OIL & GAS CO., 1 ZIEGLER   SW NW NW 33-3N-10W   (Cm-8)

1750-1760'
Cuttings
Cm-8-1

Rhyolite...... Feldspar, quartz, iron ore, chlorite, feldspar alterations, sphene-leucoxene, zircon. No phenocrysts present; reconstituted fine-grained groundmass has areas of optically continuous quartz as large as 2 mm; some vague spherulites present; larger quartz-feldspar aggregates may represent coarser interspherulitic material; chlorite well disseminated; iron ore in veinlike trends; sphene-leucoxene associated with small zircons; the thin section is slightly thick, making determinations of fine-grained rock difficult. Grain size: 0.07 mm average. Texture: relict spherulitic and felted.

This well contains reconstituted Carlton rhyolite which is unusual in that phenocrysts are absent. In the area are several wells in which the rhyolite has been altered and silicified.

WARD DAYTON, 3 RYAN   NE NW NE 3-2N-10W   (Cm-12)

2660-2670'
Cuttings
Cm-12-2

Altered rhyolite porphyry...... Quartz, clay-sericite, feldspar(?), biotite, leucoxene, iron ore, zircon(?). A highly silicified rhyolite porphyry with relict phenocrysts completely altered to sericite; clay-sericite replaces most of the groundmass feldspar but some residual material locally remains; rather coarse vein quartz replaces portion of the groundmass; relict flow lines outlined by iron ore trails. Grain size: variable. Texture: xenomorphic and relict porphyritic.

This is a good example of the alteration of rocks in the Carlton Rhyolite Group that characterizes this immediate area.

SINCLAIR PRAIRIE, 1 AUSTIN   NW SW SW 6-2N-9W   (Cm-23)

4773'
Cuttings
Cm-23-1

Diabase...... Plagioclase (46%), chlorite (12%), calcite (10%), pyroxene (9%), iron ore (7%), feldspar alterations (5%), biotite (4%), quartz (4%), sphene-leucoxene (3%), apatite (tr.). Laths of labradorite (An_{54}) contain thin veins of calcite and alteration minerals; pyroxene altering to chlorite with associated calcite; sphene-leucoxene after titaniferous iron ore; quartz is late and interstitial; primary red-brown biotite altering to a green variety. Grain size: 1.2 mm average. Texture: subophitic.

This rather coarse diabase is interpreted as an intrusive dike into the Carlton Rhyolite Group.

ALLADIN PETR. CO., 1 SCHETTLER   C NE NE 9-2N-9W   (Cm-24)

8352-8372'
Core
Cm-24-1

Rhyolite porphyry...... Phenocrysts: perthite (3%), quartz (1%); groundmass (96%): feldspar alterations, iron ore, sphene-leucoxene, chlorite, zircon, apatite. Relict phenocrysts of perthite are ragged and embayed in outline and are altering to clay-sericite; clay-sericite also common as groundmass replacement; relict spherulites present in a groundmass containing much spicular quartz; small quartz phenocrysts are round and have rims of optically continuous quartz in the groundmass; sphene-leucoxene masses after titaniferous magnetite; hematite dust common through groundmass. Grain size: phenocrysts to 0.7 mm. Texture: porphyritic and relict spherulitic.

A representative of the Carlton Rhyolite Group located very near the Meers fault.

MAGNOLIA OIL CO., 5 PRICE   SE SW NE 30-2N-9W   (Cm-25)

2610-2620'
Cuttings
Cm-25-1

Rhyolite porphyry...... Phenocrysts: plagioclase (5%), perthite (4%), quartz (1%), iron ore (1%); groundmass (89%): sphene-leucoxene, chlorite, feldspar alterations, biotite, apatite, zircon. Groundmass is finely spherulitic and contains abundant spicular quartz; one large pseudomorph of deep reddish-brown fibrous biotite replaces former mafic-mineral phenocryst; feldspar phenocrysts contain sericite-zeolite-clay alterations and hematite dust; perthite wormy and embayed whereas albite is only slightly embayed; some phenocrysts are glomeroporphyritic, composite optic units. Grain size: phenocrysts to 1.5 mm. Texture: porphyritic and spherulitic.

A typical example of the Carlton Rhyolite Group containing primary spherulites, suggesting an extrusive origin.

FRANKFORT OIL CO., 1 POAF-PY-BITTY   SW SW SW 4-1S-11W   (Cm-30)

7203-7210'
Core
Cm-30-1

Spilite(?)...... Plagioclase (42%), amphibole (26%), chlorite (15%), sphene (7%), epidote (6%), calcite (3%), feldspar alterations (tr.). Uralitic hornblende has almost the exact color and pleochroism as the chlorite, both possibly after pyroxene; pink albite veins (An_8) lined with epidote crystals cut the rock; epidote also as granular masses and small crystals enclosed in calcite; granular sphene after titaniferous iron ore. Grain size: to 0.7 mm. Texture: relict subophitic.

This is an unusual rock and is unique in comparison with the other spilites from Oklahoma. The highly albitic character and the uralitic hornblende suggest it may have been a normal spilite at one time. The rock is placed tenatively in the Navajoe Mountain Basalt-Spilite Group, but it possibly could have originated as a spilitic diabase dike into the Carlton Rhyolite Group.

W. H. ATKINSON, 1 COODY NW NW NW 21-2N-9W (Cm-33)

Rhyolite porphyry...... Phenocrysts: perthite (13%), quartz (4%), iron ore (1%), plagioclase(?); groundmass (82%): chlorite, feldspar alterations, sphene-leucoxene, biotite, apatite, zircon. Portions of the groundmass are relict spherulitic to felsophyric whereas other areas have been reconstituted into patches of optically continuous quartz; groundmass also contains optically oriented spicular quartz; clots of iron ore and chlorite may be pseudomorphs after a former mafic mineral; biotite is deep blue green and apparently secondary; feldspars clouded with alterations and hematite; one feldspar phenocryst contains a completely sericitized core. Grain size: phenocrysts to 1.5 mm. Texture: porphyritic and relict spherulitic and felsophyric.

3980-3990'
Cuttings
Cm-33-1

This well penetrated a common rock type of the Carlton Rhyolite Group.

MID KANSAS, 1 COX NE SE NE 30-1S-13W (Cm-36)

Micrographic granite...... Perthite (65%), quartz (31%), iron ore (2%), chlorite (tr.), calcite (tr.), plagioclase (tr.), feldspar alterations (tr.), sphene-leucoxene (tr.), zircon (tr.). The granite is almost a complete quartz-perthite intergrowth with minor accessory minerals; unusual clay development is intergranular with sphene-leucoxene and hematite in a granular mosaic of fine crystals; chlorite is after a probable amphibole and as a thin vein mineral; perthite clouded with iron ore and alterations; micrographic intergrowth is well defined and is cuneiform in part. Photomicrograph, pl. XI-1. Grain size: to 3 mm. Texture: micrographic.

1860-1890'
Cuttings
Cm-36-1

This well is important because in it typical Wichita granite is overlain by Arbuckle Limestone, indicating that pre-Reagan erosion had stripped the rhyolite from this area and exposed the granite.

GARR-WOOLEY, 2 RYAN NE NE SE 34-3N-10W (Cm-40)

Altered rhyolite...... Quartz, clay-sericite, iron ore, chlorite, calcite, fluorite, sphene-leucoxene. This description is a composite of four thin sections, all closely allied in mineralogy and origin; no recognizable feldspar remains, as all has been modified by the formation of clay-sericite and the introduction of much quartz; lowest sample contains well-defined relict flow structure; clay is best developed where sericite is sparse; some optically continuous areas of discrete quartz are present in first two samples. Grain size: 0.01 mm average. Texture: granoblastic.

3840-4250'
Cuttings
Cm-40-1

This well penetrated 491 feet of altered rhyolite. Alteration is characteristic of the Carlton Rhyolite Group in this geographic area (see Cm-8 and Cm-12).

FLEET DRLG. CO., 1 MEEDVILLE SE SE SE 24-2N-10W (Cm-43)

Rhyolite porphyry...... Phenocrysts: perthite (6%), plagioclase (3%), quartz (2%); groundmass (89%): iron ore, chlorite, feldspar alterations, biotite, zircon. Areas of optically oriented quartz may represent former spherulites; interspherulite material is coarser and has more iron ore and feldspar; groundmass exceptionally high in dusty hematite; spicular quartz common in areas of reconstituted spherulites. Grain size: phenocrysts to 1.5 mm. Texture: porphyritic and relict spherulitic.

2250-2270'
Cuttings
Cm-43-1

A normal rock of the Carlton Rhyolite Group.

ASHCRAFT & PALMER, 3 POPE 28-2N-10W (Cm-44)

Rhyolite porphyry...... Phenocrysts: perthite (5%), quartz (3%); groundmass (92%): sericite, siderite, iron ore, clays, sphene-leucoxene, zircon. Feldspar phenocrysts altering to clay-sericite; clays in groundmass as an interlocking mosaic; siderite as rather large crystals with minor iron stain replacing feldspar phenocrysts, and in veins; areas of optically oriented spicular quartz represent former spherulites; chlorite notably absent. Grain size: phenocrysts to 2 mm. Texture: porphyritic and relict spherulitic.

1740-1750'
Cuttings
Cm-44-1

Rhyolite porphyry...... Phenocrysts: quartz (6%), potash feldspar (1%); groundmass (93%): clay-sericite, siderite, chlorite, iron ore, sphene-leucoxene, zircon. Several chips are highly altered with the feldspars replaced by clay-sericite and the groundmass quartz reconstituted; areas of optically continuous groundmass quartz to 0.6 mm in diameter, in bands which probably represent former spherulite trails in the original rhyolite; alternating bands are felsophyric in texture; hematite finely disseminated throughout the groundmass; small quartz phenocrysts are embayed; feldspar phenocrysts present as relicts with abundant chlorite replacement; siderite as veins and in masses associated with clays. Grain size: phenocrysts to 0.6 mm. Texture: porphyritic, relict spherulitic, and felsophyric.

1940-1945'
Cuttings
Cm-44-2

The siderite, quartz reconstitution, and feldspar replacement characterize this area of the Carlton Rhyolite Group.

FRANKFORT OIL CO., 1 PICKENS C SW NW 7-1S-12W (Cm-45)

Rhyolite porphyry...... Phenocrysts: feldspar (15%), quartz (4%), iron ore (2%); groundmass (79%): feldspar alterations, zircon, apatite, chlorite. Phenocrysts of both perthite and plagioclase are present but alteration and hematite dust make proportions difficult to estimate; hematite dust and veins are common throughout the rock; spherulites of quartz and feldspar are radial around phenocrysts and range from delicate and feathery to comparatively coarse and micrographic toward the outer margins of the spherulites; chlorite exceptionally rare; plagioclase slightly zoned on the outer margins; quartz phenocrysts are inferior in size and are rounded and partially embayed. Grain size: phenocrysts to 2.5 mm. Texture: porphyritic and spherulitic-micrographic.

3434-3437'
Cuttings
Cm-45-1

This well geographically separates the spilite in the Frankfort, 1 Poaf-Py-Bitty (Cm-30) from similar rocks in Tillman County. The rock found in this well is a coarser-than-normal example of the Carlton Rhyolite Group. Its presence suggests that rhyolite covered a larger area south of the Wichita Mountains and was subsequently removed by pre-Reagan erosion.

COTTON COUNTY

JOHNSON & RUSSELL, 1 HOLMES   SW SW SW 20-2S-13W   (Ct-2)

2260-2270'
Cuttings
Ct-2-1

Meta-graywacke...... Quartz, biotite, feldspar, lithic fragments, sphene-leucoxene, feldspar alterations, chlorite, iron ore, amphibole, tourmaline. Marked lineation of biotite causes microschistosity; small (0.02 mm average) biotite flakes with some retrograde chlorite and sparse amphibole are set in a chertose mosaic of quartz, this reconstituted matrix acts as an embedding agent for several types of much coarser detritus; lithic fragments are subordinate to quartz and feldspar; sphene-leucoxene as irregular intergranular masses in the matrix; iron ore is hematite as a stain. Photomicrograph, pl. XIV-3. Grain size: to 0.6 mm. Texture: clastic-crystalloblastic.

This meta graywacke belongs to the Tillman Metasedimentary Group and is somewhat unusual in that the matrix micas are aligned.

ELLISON ET AL., 1 HARRIS   NE NE 26-2S-13W   (Ct-3)

2280-2296'
Cuttings
Ct-3-1

Meta-graywacke...... Detrital grains: quartz (30%), feldspar (35%), lithic fragments (13%); matrix (22%): biotite, sphene-leucoxene, epidote, feldspar alterations, chlorite, iron ore, apatite, zircon. Particularly diverse lithic fragments include cherts, metacherts, quartzite, schist, phyllite, and fragments of acid igneous rocks; the matrix is chertose quartz with crystalloblastic biotite, epidote, and retrograde chlorite; vague lineation in the micas; detrital apatite and zircon very sparse; feldspars are dominantly sericitized perthite and orthoclase; sphene-leucoxene as ragged masses in the matrix. Grain size: to 1.3 mm., 0.3 mm average. Texture: clastic-crystalloblastic.

This rock is quite similar to that found in the Johnson and Russell, 1 Holmes (Ct-2) a few miles to the west. The polygenetic mineral fragments give excellent evidence of the diverse character of the source rocks for the Tillman Metasedimentary Group.

FRANKFORT OIL CO., 1 PHILLIPS   SW SW SE 6-3S-11W   (Ct-4)

4790-4800'
Cuttings
Ct-4-1

Rhyolite porphyry...... Phenocrysts: plagioclase (11%), iron ore (1%); groundmass (88%): potash feldspar, quartz, chlorite, calcite, feldspar alterations, apatite. Phenocrysts of sodic oligoclase clustered in one small area; iron ore as dust and small granules, mostly hematite; relict spherulites associated with spicular quartz; chlorite very irregular and is concentrated near calcite and iron ore. Grain size: phenocrysts to 0.9 mm. Texture: porphyritic and relict spherulitic.

A common rock of the Carlton Rhyolite Group found along the Muenster arch.

AMERADA PETR. CORP., 1 DELANA   SE NW NW 31-4S-9W   (Ct-5)

3287-3290'
Cuttings
Ct-5-1

Rhyolite porphyry...... Phenocrysts: plagioclase (13%), sphene-leucoxene (2%), pyrite (1%); groundmass (84%): potash feldspar, quartz, chlorite, epidote, feldspar alterations, calcite, iron ore, apatite, zircon. Groundmass contains relict primary spherulites around phenocrysts of albite; pyrite common as small cubes; clouding of feldspars caused by alteration and iron ore dust; sphene-leucoxene masses replace titaniferous magnetite granules; epidote as small, secondary crystals in groundmass, occasionally grouped. Grain size: phenocrysts to 1.4 mm. Texture: porphyritic and relict spherulitic.

The primary spherulites suggest an extrusive origin for this member of the Carlton Rhyolite Group.

KEWANEE OIL CO., 12 WOOK-KAH-NAH   E½ NE SW 1-4S-11W   (Ct-7)

4150-4160'
Cuttings
Ct-7-1

Rhyolite porphyry...... Phenocrysts: feldspar (6%), quartz (3%), iron ore (2%); groundmass (89%): chlorite, calcite, sericite, apatite, zircon. Exceptionally delicate micrographic intergrowth of quartz and feldspar comprises most of the groundmass; some intergrowth is radial and approaches spherulitic character; sparse unidentified feldspar phenocrysts are altering to sericite and being replaced by chlorite; hematite follows trends as a replacement mineral; some needles of iron ore are parallel to radial micrographic intergrowth. Grain size: phenocrysts to 1 mm. Texture: porphyritic, micrographic, and spherulitic.

The rock described is a member of the Carlton Rhyolite Group. Lower in the well is a rather complex contaminated diabase.

CHRISTIE-STEWART, 1 SANDERS   NE NE SE 15-3S-12W   (Ct-9)

3380-3402'
Cuttings
Ct-9-1

Micrographic granite porphyry(?)...... Perthite (47%), quartz (34%), plagioclase (8%), chlorite (7%), iron ore (3%), biotite (tr.), hornblende (tr.), calcite (tr.), feldspar alterations (tr.), sphene (tr.), apatite (tr.), zircon (tr.). Crudely micrographic quartz and feldspar present with discrete feldspar that is suggestive of a porphyry; chlorite locally very abundant and is generally after hornblende with calcite and biotite in association; sphene as granules around titaniferous iron ore. Grain size: to 2 mm. Texture: micrographic and porphyritic.

This well penetrated rock in the thin band of the Wichita Granite Group that separates the Tillman metasediments from the Carlton rhyolite along the northwestern extension of the Muenster arch.

GARVIN COUNTY

STANOLIND OIL & GAS CO., 1 ALLSUP C NW NW 34-1N-1W (Gv-1)

9800-9850'
Cuttings
Gv-1-1

Rhyolite porphyry...... Phenocrysts: plagioclase (16%), iron ore (3%); groundmass (81%): potash feldspar, quartz, chlorite, calcite, leucoxene, feldspar alterations, zircon, apatite. Groundmass varies between silicified-chertose and highly spicular feldspars containing much hematite dust; chlorite in veins and masses of unoriented shreds; titaniferous magnetite in granules, veins and crystallites, altering to leucoxene and hematite; zircon and apatite associated with iron ore. Grain size: phenocrysts to 1.5 mm. Texture: porphyritic and felsophyric.

9850-9900'
Cuttings
Gv-1-3

Silicified rhyolite tuff...... Cementing groundmass (54%), potash feldspar (43%), iron ore (3%), quartz, plagioclase, calcite, chlorite, sericite. Exceptionally abundant feldspar crystals are set in a matrix of chertose quartz; these crystals contain much hematite and are altered, while the matrix feldspars are comparatively clear; sericite in masses of shreds in matrix; calcite as an irregular replacement; iron ore granules altering to minor leucoxene. Grain size: to 1.5 mm. Texture: clastic and xenomorphic.

9932-9943'
Cuttings
Gv-1-2

Rhyolite porphyry...... Phenocrysts: plagioclase (9%), potash feldspar (7%), quartz (1%); groundmass (83%): iron ore, chlorite, calcite, feldspar alterations, leucoxene, zircon, apatite. Areas of optically continuous spicular quartz developed in groundmass; sparse quartz phenocrysts have an optically continuous rim of groundmass quartz; one chip appears silicified; feldspars altering to clay and sericite; calcite as an irregular replacement. Grain size: phenocrysts to 1.2 mm. Texture: porphyritic and felsophyric.

This sequence of rhyolite and related tuff is in the Carlton Rhyolite Group.

KILGORE ET AL., 1 WILLIAMS SE NE SW 20-1N-2W (Gv-7)

2640-2650'
Cuttings
Gv-7-1

Altered rhyolite porphyry...... Quartz, clay-sericite, iron ore, feldspar, chlorite, calcite, sphene-leucoxene. Abundant introduced hematite and chalcedonic quartz dominate portions of the rock; groundmass feldspars partly replaced by clay-sericite whereas phenocrysts have been completely replaced; sphene-leucoxene highly irregular in distribution. Grain size: relicts to 0.5 mm. Texture: relict porphyritic and felsophyric.

2687-2705'
Cuttings
Gv-7-2

Rhyolite porphyry...... Phenocrysts: plagioclase (3%); groundmass (97%): potash feldspar, quartz, calcite, iron ore, chlorite, biotite, clay-sericite, leucoxene. Sparse phenocrysts of plagioclase contain sericite alterations; groundmass appears to be relict spherulitic with areas of optically continuous spicular quartz; clay-sericite alterations advanced in groundmass; hematite in veins; biotite as secondary vein. Grain size: phenocrysts to 0.5 mm. Texture: porphyritic and relict spherulitic.

The high degree of alteration of these rhyolites is not uncommon in the area surrounding the East and West Timbered Hills. The rock is a member of the Carlton Rhyolite Group.

SOHIO OIL CO., 1A KENNEDY NW NW SE 26-1N-2W (Gv-8)

5630-5640'
Cuttings
Gv-8-1

Rhyolite porphyry...... Phenocrysts: plagioclase (7%); groundmass (93%): potash feldspar, quartz, calcite, iron ore, pyrite, feldspar alterations, zircon, apatite. Groundmass contains areas of optically oriented spicular quartz intergrown with feldspar containing much hematite; phenocrysts are mostly euhedral with some hematite staining and sericite alterations; calcite and chlorite in veins and masses; iron ore dust common throughout the groundmass. Grain size: phenocrysts to 1.5 mm. Texture: porphyritic and felsophyric.

5650-5660'
Cuttings
Gv-8-2

Perlitic rhyolite porphyry...... Phenocrysts: potash feldspar (7%); groundmass (93%): quartz, plagioclase, iron ore, sphene-leucoxene, biotite, amphibole, chlorite, zircon. Very fine-grained devitrified groundmass of quartz and feldspar; unusual occurrence of amphibole granules disseminated through the groundmass; perlitic cracks exceptionally well defined, outlined by iron ore and sphene-leucoxene granules; iron ore dust disseminated through groundmass in ragged to rounded particles; zircon abundant in small crystals. Grain size: phenocrysts to 0.7 mm. Texture: porphyritic and perlitic.

5790-5800'
Cuttings
Gv-8-3

Altered andesine diabase...... Plagioclase, calcite, chlorite, iron ore, feldspar alterations, amphibole, sphene, apatite, zircon. Laths of andesine altering to sericite, portions in advanced stages; sphene exceptionally common and well developed; primary pyroxene completely altered to chlorite and uralitic hornblende with sphene as a by-product; calcite replaces large portions of the original minerals. Grain size: to 1.2 mm. Texture: relict subophitic or intergranular.

6280-6290'
Cuttings
Gv-8-4

Rhyolite porphyry...... Phenocrysts: plagioclase (11%), groundmass (89%): potash feldspar, quartz, iron ore, leucoxene, chlorite, calcite, biotite, fluorite, apatite. Euhedral albite phenocrysts set in a groundmass of relict spherulitic spicular quartz-feldspar intergrowth; calcite and chlorite abundant as secondary minerals; biotite(?) associated with calcite veins as tiny shreds; iron ore as crystallites and small granules; leucoxene pseudomorphous after titaniferous magnetite. Grain size: phenocrysts to 1 mm. Texture: porphyritic and relict spherulitic.

6800-6810'
Cuttings
Gv-8-5

Rhyolite porphyry..... Perthite phenocrysts (9%), groundmass (91%): quartz, iron ore, calcite, plagioclase, clay-sericite, chlorite, sphene-leucoxene, zircon. Veins of coarser rhyolitic material are present with some cavity-like fillings; calcite as an irregular replacement; sphene-leucoxene as small crystals and as an alteration of titaniferous magnetite; groundmass appears to be partly silicified; feldspars replaced by clay-sericite; iron ore dust irregularly disseminated through the groundmass. Grain size: phenocrysts to 1.2 mm. Texture: porphyritic and xenomorphic.

6880-6890'
Cuttings
Gv-8-6

Rhyolite porphyry...... Phenocrysts: plagioclase (4%), perthite (3%); groundmass (93%): quartz, iron ore, calcite, feldspar alterations, chlorite, sphene-leucoxene, zircon. Well-developed flow lines appear to be alternately high in quartz or feldspar; sphene-leucoxene abundant as specks in groundmass and around titaniferous magnetite; banding causes variable grain size in groundmass; feldspar phenocrysts are altered and contain hematite as dust. Grain size: phenocrysts to 1.6 mm. Texture: porphyritic and felted.

Sohio Oil Co., 1A Kennedy (cont.)

7170-7180'
Cuttings
Gv-8-7

Rhyolite...... Feldspar, quartz, calcite, iron ore, chlorite, biotite, feldspar alterations, sphene-leucoxene. Some small crystals are slightly larger than the average but cannot be considered phenocrysts; chips appear brecciated in ordinary light because of irregular silicification veins containing much less hematite than does the groundmass; relicts of a felted groundmass are present in the chertose quartz mosaic; biotite as tiny secondary flakes. Grain size: to 0.5 mm. Texture: relict felted to xenomorphic.

7200-7220'
Cuttings
Gv-8-8

Rhyolite...... Potash feldspar, quartz, plagioclase, calcite, micas, sphene-leucoxene, iron ore, feldspar alterations, fluorite. Some rare euhedral "infant" phenocrysts to 0.12 mm long; sericite associated with biotite and chlorite; calcite as small replacement blebs and veins; hematite dust disseminated through the groundmass; fluorite as a late mineral associated with mica masses. Grain size: 0.1 mm. Texture: felted to xenomorphic.

7310-7330'
Cuttings
Gv-8-9

Rhyolite porphyry...... Perthite phenocrysts (6%); groundmass (94%): quartz, plagioclase, calcite, micas, iron ore, feldspar alterations, sphene-leucoxene, zircon, apatite. Areas of optically oriented quartz well developed near late quartz veins; phenocrysts of perthite are sparse, some with well-developed Carlsbad twins; chlorite and sericite as disseminated shreds in linear trends; iron ore in small irregular blebs and as dust through the groundmass. Grain size: phenocrysts to 0.8 mm. Texture: porphyritic and felted.

7430-7440'
Cuttings
Gv-8-10

Rhyolite and arkose...... Potash feldspar, quartz, plagioclase, clay-sericite, calcite, iron ore, chlorite, sphene-leucoxene, zircon. Rhyolite extremely fine grained and characterized by secondary silicification; magnetite-hematite veins cut several chips; "infant" feldspar phenocrysts present; arkose is fairly well sorted, containing diverse feldspar fragments including microcline; clay-sericite as a common intergranular material in the arkose and some muscovite appears to be detrital; the most unusual feature of the arkose is a lack of lithic rhyolite detritus. Grain size: 0.03 mm in rhyolite; 0.1 mm in arkose. Texture: felted to xenomorphic in the rhyolite, clastic in the arkose.

7460-7470'
Cuttings
Gv-8-11

Silicified rhyolite...... Quartz, feldspar, iron ore, calcite, micas, feldspar alterations. Extremely fine-grained mosaic with feldspars identified only in the relict felted portions of the groundmass; iron ore veins have no apparent pattern; micas finely disseminated; calcite as minor veins and masses; most of the slide composed of chertose quartz and associated iron ore. Grain size: 0.02 mm. Texture: xenomorphic and relict felted.

7540-7560'
Cuttings
Gv-8-12

Altered rhyolite porphyry(?)...... Quartz, calcite, clay-sericite, feldspar, sphene-leucoxene, chlorite, iron ore. Groundmass is composed of extremely fine-grained chertose quartz containing much calcite replacement; irregular spherulites and phenocrystlike material could be relicts of a silicified rhyolite or tuffaceous detritus in a reconstituted dust matrix; clay material clouds in several chips; iron ore is present as a stain; chlorite as tiny disseminated flakes. Grain size: "cement" 0.005 mm average; "phenocrysts" to 0.2 mm. Texture: xenomorphic and relict porphyritic(?).

7640-7650'
Cuttings
Gv-8-13

Mylonized rhyolite porphyry...... Clay-silica paste, quartz, calcite, micas, sphene-leucoxene, perthite, plagioclase, iron ore. Highly lineated rhyolite porphyry with calcite generally outlining the mylonitic trends; relict "eyes" of phenocrysts and groundmass fragments are preserved in linear elements; some mylonized areas are high in sericite and chlorite contents but most are a cloudy

Sohio Oil Co., 1A Kennedy (cont.)

paste of clay and silica; sphene-leucoxene as small granules. Grain size: relict "eyes" to 0.4 mm. Texture: cataclastic.

8125-8135'
Cuttings
Gv-8-14

Micrographic micrgranite porphyry...... Perthite (61%), quartz (34%), plagioclase (2%), chlorite (2%), iron ore (1%), calcite (tr.), feldspar alterations (tr.), sphene-leucoxene (tr.), biotite (tr.), apatite (tr.), zircon (tr.). A very delicate micrographic intergrowth of quartz and feldspar with minor perthite phenocrysts; biotite with some sericite in semispherulitic masses and as normal books altering to chlorite; titaniferous magnetite as numerous small granules with a partial to total rim of sphene-leucoxene. Grain size: 0.7 mm average. Texture: porphyritic and micrographic.

8275-8285'
Cuttings
Gv-8-15

Altered basic intrusion...... Plagioclase, micas, amphibole, iron ore, potash feldspar, quartz, epidote, pyroxene, sericite, sphene-leucoxene, apatite, zircon. Plagioclase is poorly twinned and highly altered to sericite; pyroxene altering to chlorite, biotite and uralitic hornblende; some sparse micrographic intergrowth; epidote occurs as discrete crystals and as replaced cores of large plagioclase laths; hematite dust clouds feldspars; this rock is probably an intrusion that has been contaminated by the surrounding granite. Grain size: 0.2 mm average, phenocrysts to 1.1 mm. Texture: hypidiomorphic and porphyritic.

8925-8935'
Cuttings
Gv-8-16

Microgranite...... Perthite, quartz, plagioclase, hornblende, iron ore, chlorite, sphene, apatite, zircon. Feldspar alterations irregular, as areas of clear feldspar alternate with highly turbid material; hornblende is large, well formed, and unusually abundant; chlorite is a pennine type in part; grain size differs among chips; titaniferous magnetite has sphene in association. Grain size: 0.2 mm average. Texture: xenomorphic.

9345-9355'
Cuttings
Gv-8-17

Micrographic granite porphyry...... Perthite (65%), quartz (32%), chlorite (1%), iron ore (1%), calcite (tr.), sphene-leucoxene, fluorite (tr.), biotite (tr.), zircon (tr.). No free plagioclase noted; perthite is both in a delicate intergrowth with quartz and as discrete phenocrysts; magnetite associated with biotite and fluorite; chlorite appears to be after a former mafic mineral and as secondary masses of shreds; feldspar is clouded by heamtite dust and minor alterations. Grain size: to 2.7 mm. Texture: micrographic and porphyritic.

9570-9580'
Cuttings
Gv-8-18

Granite...... Perthite (66%), quartz (29%), plagioclase (2%), chlorite (1%), iron ore (1%), calcite (tr.), feldspar alterations (tr.), sphene-leucoxene (tr.), fluorite (tr.), apatite (tr.), zircon (tr.). This is a common type of Wichita granite; the feldspars are clouded with minor alterations and hematite dust; minor free plagioclase occurs as a sparse intergranular mineral; magnetite granules are associated with apatite and zircon. Photomicrograph, pl. XI-4. Grain size: to 2.5 mm. Texture: hypidiomorphic.

9975-9985'
Cuttings
Gv-8-19

Granite...... Perthite (64%), quartz (28%), chlorite (4%), iron ore (2%), plagioclase (1%), feldspar alterations (tr.), calcite (tr.), sphene-leucoxene (tr.), biotite (tr.), apatite (tr.), zircon (tr.). Entirely similar to the previous sample with the exception of an increased chlorite content, with some biotite in association; feldspars slightly turbid; apatite as tiny acicular inclusions; zircon associated with titaniferous magnetite. Grain size: to 1.5 mm. Texture: hypidiomorphic.

This well and the Frankfort, 1 Sparks (Mr-1) each was drilled within five miles of outcropping Carlton rhyolite (Colbert porphyry) in the Arbuckle anticline, at the western edge of the Arbuckle Mountains. Each penetrated Wichita granite under thick Carlton rhyolite. These relations are the same as in the Wichita

Sohio Oil Co., 1A Kennedy (cont.)
Mountain area, and the two Arbuckle Mountain wells are therefore important in establishing a correlation between the two areas.
This well was drilled in a structurally complex area, as a result of which it is difficult to estimate the true thickness of rhyolite and granite.

FAIN-PORTER DRLG. CO., 1 MAYES UNIT C SW NE 9-1N-3W (Gv-10)

Rhyolite porphyry...... Plagioclase phenocrysts (12%); groundmass (88%): potash feldspar, quartz, iron ore, calcite, feldspar alterations, chlorite, sphene-leucoxene, apatite. Single and multiple phenocrysts are set in a groundmass of felsophyric quartz and feldspar containing reddish primary feathery spherulites; groundmass contains exceptionally abundant iron ore crystallites; chlorite is in sparse masses; sericite developed in large sparse flakes. Grain size: phenocrysts to 1.3 mm. Texture: porphyritic spherulitic and felsophyric.

7680-7690'
Cuttings
Gv-10-1

This well penetrated 316 feet of the Carlton Rhyolite Group before passing through a thrust fault back into Paleozoic strata. It is the most westerly of the wells penetrating rhyolite in the subsurface extension of the Arbuckle Mountains.

GREER COUNTY

JOHN HENDERSON, 1 DUGGER SW SW NE 7-7N-23W (Gr-1)

Granite...... Perthite (54%), quartz (31%), plagioclase (11%), iron ore (2%), chlorite (1%), sericite (tr.), biotite (tr.), zircon (tr.). Perthite contains dusty hematite; plagioclase altering to minor sericite; pennine-type chlorite as pseudomorphs after biotite; relict biotite highly stained with iron ore; hematite common as a vein mineral. Grain size: to 1.5 mm. Texture: hypidiomorphic.

1680-1705'
Cuttings
Gr-1-1

This well was drilled in the Wichita granite, in the band separating gabbroic rocks from Carlton rhyolite.

NEAL ET AL., 1 DOOLEY NW NW NW 1-7N-22W (Gr-2)

Granite...... Microcline perthite (63%), quartz (34%), iron ore (2%), plagioclase (1%), biotite (tr.), apatite (tr.), zircon (tr.), feldspar alterations (tr.). Microcline perthite slightly turbid; free oligoclase is rare and gradational with patch-type perthite; biotite in small poorly formed crystals; zircon is large and associated with iron ore or as discrete crystals included in quartz or perthite. Grain size: to 2 mm. Texture: hypidiomorphic.

1550-1575'
Cuttings
Gr-2-1

This well was drilled into the band of Wichita granite separating the Raggedy Mountain Gabbro Group from the Carlton Rhyolite Group. The granite is somewhat unusual in that it carries microcline as the potash feldspar of the perthite. The low content of femic minerals is typical of the Wichita Granite Group.

BOLIN OIL CO., 1 MAGNOLIA SW SE 15-7N-22W (Gr-4)

Altered gabbro...... Plagioclase, calcite, chlorite, biotite, iron ore, tremolitic amphibole, sericite, feldspar alterations, acicular inclusions. Sericite in large masses and in well-formed books associated with iron ore; several varieties of chlorite present as alteration of former pyroxene and a vein mineral; some brecciation present with attendant alteration products; plagioclase irregularly mottled with alterations. Grain size: 7 mm+. Texture: hypidiomorphic.

1629-1660'
Cuttings
Gr-4-1

Mylonized gabbro...... Clay paste, calcite, zeolite, plagioclase, iron ore. Most of the rock is an ultrafine-grained claylike paste with zeolite development and minor shreds of chlorite; calcite common as a vein mineral; plagioclase relicts are highly altered; iron ore as dust; lineation is not marked. Grain size: relicts to 4 mm. Texture: cataclastic.

1730-1750'
Cuttings
Gr-4-2

This well is located along the buried axial core of the Wichita Mountains. The cataclastic alteration is not unusual in the Raggedy Mountain Gabbro Group.

STEPHENS PETR. CO., 1 SCHOOL LAND NW NW SE 16-7N-21W (Gr-10)

Gabbro...... Plagioclase, chlorite, calcite, tremolitic amphibole, iron ore, clay-zeolite, epidote, sericite, pyroxene, sphene, acicular inclusions. Labradorite clouded with clay-zeolite alterations; small relicts of pyroxene in chlorite and tremolitic amphibole; calcite as irregular replacement; very fine needles of unidentified inclusions in plagioclase; epidote as small irregular crystals. Grain size: 4 mm+. Texture: hypidiomorphic.

1390-1414'
Cuttings
Gr-10-1

An altered gabbro of the Raggedy Mountain Gabbro Group.

GRAGG OIL CO., 1 HEATLEY SW NW NW 3-6N-24W (Gr-13)

Rhyolite porphyry...... Phenocrysts: plagioclase (6%), iron ore (1%); groundmass (93%): potash feldspar, quartz, biotite, chlorite, sericite.

1445-1450'
Cuttings
Gr-13-1

Phenocrysts of oligoclase are clouded with alterations and hematite dust; mildly pleochroic biotite altering to a blue-green variety of chlorite; iron ore granules have a delicately ragged margin; spherulites are delicately micrographic at outer margins and contain feathery iron ore parallel to radial spheroids. Grain size: phenocrysts to 1 mm. Texture: porphyritic and spherulitic.

A typical rock in the large tract of Carlton rhyolite in Greer and Beckham Counties.

DECKER, READ & I. T. I. O., 1 FOSTER C SW NE 17-6N-24W (Gr-14)

Rhyolite porphyry...... Phenocrysts: plagioclase (11%), iron ore (2%); groundmass (87%): perthite, quartz, chlorite, calcite, sericite, epidote, sphene, apatite.

2350'
Core
Gr-14-1

Glomeroporphyritic plagioclase crystals have complex twinning; chlorite locally abundant; calcite in intergranular masses is optically continuous over several grains; hematite as dust disseminated through groundmass and as alteration of magnetite granules. Grain size: phenocrysts to 2 mm. Texture: felted and porphyritic.

Rhyolite porphyry...... Phenocrysts: plagioclase (9%), iron ore (2%); groundmass (89%): perthite, quartz, chlorite, calcite, sericite, sphene, apatite, zircon.

2395-2404'
Cuttings
Gr-14-2

Albite phenocrysts characterized by ragged edges are set in a felted groundmass of quartz and perthite with plagioclase, minor chlorite, and iron ore; calcite replaces irregularly; sphene in small granular masses associated with iron ore; albite replaced by minor calcite and sericite. Grain size: phenocrysts to 2.5 mm. Texture: porphyritic and felted.

Rhyolite porphyry...... Phenocrysts: plagioclase (4%), iron ore (2%); groundmass (94%): perthite, quartz, chlorite, calcite, sericite, sphene, apatite, zircon.

2405-2425'
Cuttings
Gr-14-3

Groundmass contains much iron ore, mostly hematite but titaniferous magnetite altering to sphene does occur; chlorite contains iron ore in association; phenocrysts less abundant than in previous samples. Grain size: phenocrysts to 0.7 mm. Texture: porphyritic and xenomorphic.

Diabase porphyry...... Plagioclase, chlorite, iron ore, feldspar alterations, biotite, uralitic hornblende, calcite, sphene, apatite.

2455-2465'
Cuttings
Gr-14-4

One chip is extremely fine grained and only sparse plagioclase laths can be recognized in an opaque to subisotropic groundmass of submicroscopic minerals; plagioclase is highly altered and was not determined; chlorite and uralitic hornblende replace former mafic mineral; sphene as granular masses. Grain size: phenocrysts to 1 mm. Texture: porphyritic, relict subophitic, and relict hyalopilitic.

The well penetrated rocks of the Carlton Rhyolite Group, with a younger chilled diabase at the bottom of the hole.

GRAGG OIL CO., 1 HALFORD SE SE SE 23-6N-24W (Gr-16)

Rhyolite porphyry...... Phenocrysts: plagioclase (7%), iron ore (4%); groundmass (89%): perthite, quartz, chlorite, feldspar alterations, biotite, sphene, apatite, zircon, calcite.

1395-1405'
Cuttings
Gr-16-1

Albite phenocrysts altering to minor sericite and contain hematite dust; biotite-sericite-chlorite masses have anomalous optical properties; dust and microlite forms of hematite common in groundmass;

Gragg Oil Co., 1 Halford (cont.)

feathery spherulites present in groundmass; spicular quartz in groundmass up to 1 mm long and 0.02 mm wide. Grain size: phenocrysts to 1 mm. Texture: porphyritic and spherulitic.

Rhyolite porphyry...... Phenocrysts: plagioclase (6%), iron ore (2%); groundmass (92%): potash feldspar, quartz, chlorite, feldspar alterations, sphene, apatite, zircon.

1500-1510'
Cuttings
Gr-16-2

Phenocrysts of plagioclase are invaded by iron ore and alterations; delicate, hairlike, opaque material common in groundmass; groundmass is mostly feathery quartz-feldspar spherulites. Grain size: phenocrysts to 1.5 mm. Texture: porphyritic and spherulitic.

This well is located in an area of numerous basement-rock tests, all of them penetrating rocks of the Carlton Rhyolite Group.

AN-SON PETR. CORP., 1 WARE SW NW NW 30-4N-22W (Gr-33)

Micrographic microgranite porphyry...... Potash feldspar, quartz, plagioclase, chlorite, iron ore, sphene, calcite, sericite, biotite, apatite, zircon.

4737-4750'
Cuttings
Gr-33-1

Very delicate micrographic intergrowth well defined and nonspherulitic; phenocrysts of plagioclase and minor perthite are roughly twice the size of groundmass crystals; alteration and iron stain on plagioclase makes determination impossible. Grain size: phenocrysts to 0.6 mm. Texture: porphyritic and micrographic.

This rock probably represents the chilled margin of Wichita granite. The granite is overlain by Royer Dolomite, suggesting that the area was topographically high during and immediately following Reagan time.

ABILENE OIL CO., 1A LUKER SE SE SE 6-4N-21W (Gr-35)

Olivine diabase...... Plagioclase (46%), pyroxene (19%), iron ore (11%), olivine (7%), iddingsite (6%), chlorite (6%), feldspar alterations (5%), biotite (tr.), apatite (tr.).

2157-2165'
Cuttings
Gr-35-1

Labradorite laths locally altered to sericite and zeolites; iddingsite replaces portions of the original olivine; biotite is rose red and primary, altering to a fibrous green variety; plagioclase is strongly zoned in the larger crystals; chlorite replaces pyroxene irregularly; pyroxene has the purple tinge of titaniferous augite. Grain size: to 2 mm. Texture: subophitic.

It is unfortunate that a well located in this area did not penetrate a more definitive rock type. From surrounding wells and general basement configuration, the rock is considered to be a diabase intruding the Wichita Granite Group.

BRIDWELL OIL CO., 1 ARNOLD NE NW SE 5-3N-22W (Gr-37)

Micrographic microgranite porphyry...... Potash feldspar, quartz, plagioclase, chlorite, iron ore, calcite, epidote, sphene, biotite, feldspar alterations, apatite, zircon.

4500-4550'
Cuttings
Gr-37-1

Very delicate micrographic intergrowth; feldspars highly clouded with alterations and hematite dust; plagioclase as sericitized phenocrysts; epidote occurs with chlorite; chlorite is a blue-green highly pleochroic variety. Grain size: phenocrysts to 1.5 mm, 0.4 mm average. Texture: Micrographic and porphyritic.

This rock is quite similar to the An-Son Petr., 1 Ware a few miles to the north. Both of these wells are interpreted as penetrating chilled phases of the Wichita Granite Group.

HARVEY DRILLING CO., 1 BARR SE SE NE 2-3N-23W (Gr-38)

A few chips of feldspar at total depth of 5,305 feet suggest that basement-rock granite of the Wichita Group was penetrated.

COLUMBIAN FUEL CORP., 2 JOHNSON SW SW NE 26-6N-22W (Gr-44)

Granite...... Perthite (64%), quartz (34%), iron ore (1%), chlorite (tr.), calcite (tr.), riebeckite (tr.), sericite (tr.), apatite (tr.), zircon (tr.).
676-683' Cuttings Gr-44-1 Small riebeckite crystals enclosed in perthite are in bundles of acicular, radial groups; perthite slightly turbid; chlorite-calcite masses after riebeckite; sericite after perthite. Grain size: to 2.5 mm. Texture: hypidiomorphic.

The granites of this area in Greer County generally contain small amounts of riebeckite. The rock is an example of the Wichita Granite Group.

COLUMBIAN FUEL CORP., 1 HARRIS NW SE NW 34-7N-24W (Gr-46)

Rhyolite porphyry...... Phenocrysts: plagioclase (6%), iron ore (4%); groundmass (90%): potash feldspar, quartz, chlorite, biotite,
1591-1618' Cuttings Gr-46-1 sericite, sphene-leucoxene. Plagioclase phenocrysts highly altered to sericite; rock contains much granular iron ore as magnetite and abundantly disseminated hematite; groundmass is essentially structureless. Grain size: phenocrysts to 1.5 mm. Texture: porphyritic and felsophyric.

A common member of the Carlton Rhyolite Group.

COLUMBIAN FUEL CORP., 1 RICHARDS SW NE SW 11-6N-24W (Gr-47)

Rhyolite porphyry...... Phenocrysts: plagioclase (9%), iron ore (3%); groundmass (88%): potash feldspar, quartz, chlorite, calcite,
1227-1287' Cuttings Gr-47-1 biotite, feldspar alterations, apatite. Minor zeolites replace patches in plagioclase phenocrysts; groundmass is locally coarse and contains abundant blue-green chlorite and finely disseminated hematite; some quartz has a spicular form; calcite as irregular flakelike forms; biotite is secondary. Grain size: phenocrysts to 2 mm. Texture: porphyritic and felsophyric.

A rock similar to that in Columbian Fuel Corp., 1 Harris a few miles to the north, and a typical rock of the Carlton Rhyolite Group in Greer County.

COLUMBIAN FUEL CORP., STRAT. TEST No. 1 SE SE NE 26-6N-22W (Gr-48)

Micrographic granite porphyry...... Perthite (65%), quartz (33%), iron ore (1%), calcite (tr.), sericite (tr.), amphibole (tr.), zircon (tr.). Perthite
880-890' Cuttings Gr-48-1 turbid with alterations and hematite dust; perthite may be microcline; phenocrysts are much less turbid; sparse shreds of amphibole are the only suggestion of a femic mineral present. Grain size: to 2 mm+. Texture: porphyritic and micrographic.

The extremely low content of femic minerals, the micrographic intergrowth, and a lack of free plagioclase make this rock an excellent example of the Wichita Granite Group.

COLUMBIAN FUEL CORP., STRAT. TEST No. 4 NE SE NE 27-6N-22W (Gr-49)

Micrographic granite...... Perthite (63%), quartz (31%), calcite (3%), iron ore (2%), feldspar alterations (tr.), riebeckite (tr.), biotite (tr.),
738-740' Core Gr-49-1 zircon (tr.). Delicate intergrowth of quartz and perthite; riebeckite as small, somewhat acicular crystals associated with magnetite granules; biotite as shreds, very small and intergranular; perthite faintly clouded with alterations and hematite dust. Grain size: to 3.5 mm. Texture: micrographic.

The rock penetrated in this well is typical of the Wichita Granite Group in central Greer County.

COLUMBIAN FUEL CORP., STRAT. TEST No. 6 NW NW NE 22-6N-22W (Gr-50)

Gabbroic diorite...... Labradorite (51%), amphibole (19%), biotite (9%), iron ore (7%), quartz (4%), chlorite (3%), pyroxene (2%), sericite (2%),
1250-1262' Cuttings Gr-50-1 sphene (tr.), apatite (tr.). Plagioclase (An_{52}) altering to minor sericite, larger crystals are zoned; calcite dominates one chip, replacing both plagioclase and former mafic mineral; quartz is interstitial and apparently primary; deep-green primary hornblende associated with well-crystallized books of red-brown biotite. Grain size: to 2 mm. Texture: hypidiomorphic.

A rock transitional between gabbro and diorite of the Raggedy Mountain Gabbro Group. The well is within a mile of other basement tests that penetrate granite.

COLUMBIAN FUEL CORP., STRAT. TEST No. 7 SE SE NE 28-6N-22W (Gr-51)

Granite porphyry...... Perthite, quartz, plagioclase, iron ore, biotite, feldspar alterations, calcite, chlorite, apatite, zircon. Large phenocrysts
1313-1321' Cuttings Gr-51-1 of perthite contain poikilitically enclosed biotite, quartz, and unoriented perthite; the rock is coarse and textural relationships are obscure; large quartz crystals are faintly strained; biotite is deep red brown. Grain size: to 6 mm. Texture: hypidiomorphic and porphyritic.

This well penetrated the coarsest granite found in Greer County. It is an example of the Wichita Granite Group.

COLUMBIAN FUEL CORP., STRAT. TEST No. 2 SW SW SE 35-6N-22W (Gr-52)

Granite...... Samples from this well are too poor for petrographic examination, but the rock is thought to be allied to the Wichita Granite Group.

COLUMBIAN FUEL CORP., 1 TAYLOR NE SE SW 23-6N-22W (Gr-53)

Micrographic granite porphyry...... Perthite (66%), quartz (32%), iron ore (1%), chlorite (tr.), feldspar alterations (tr.), hornblende, riebeckite,
817-122' Cuttings Gr-53-1 calcite, sphene, zircon. Perthite is clouded with alterations and hematite dust; perthite phenocrysts are not intergrowth with quartz; riebeckite in small acicular crystals associated with common hornblende; micrographic intergrowth is rather coarse and is not radial around phenocrysts; a few large quartz grains are discrete. Grain size: to 3 mm+. Texture: porphyritic and micrographic.

A representative of the Wichita Granite Group.

COLUMBIAN FUEL CORP., 1 SCHUMATE SW NE NW 26-6N-22W (Gr-54)

549'
Cuttings
Gr-54-1

Micrographic granite...... Perthite (63%), quartz (35%), iron ore (1%), chlorite (tr.), feldspar alterations (tr.), riebeckite (tr.), hornblende (tr.), biotite (tr.), apatite (tr.), zircon (tr.). Very low percentage of accessory minerals, particularly femics, is noted; riebeckite as a late intergranular mineral and in small, acicular crystals; perthite is mostly a string type and is irregularly clouded; hornblende associated with iron ore. Grain size: to 2 mm. Texture: micrographic.

The presence of riebeckite and an extremely low content of accessory minerals characterizes the Wichita Granite Group in Greer County.

COLUMBIAN FUEL CORP., 1 TAYLOR NW SE SE 22-6N-23W (Gr-55)

825'
Cuttings
Gr-55-1

Gabbroic diorite...... Plagioclase (54%), amphibole (17%), pyroxene (9%), biotite (6%), iron ore (6%), feldspar alterations (2%), chlorite (3%), quartz (1%), apatite (tr.). Labradorite (An_{54}) clouded with alterations; pyroxene contains magnetite granules and rods; hornblende as reaction rims around pyroxene and as discrete well-formed crystals; biotite is red brown and primary. Grain size: to 2 mm. Texture: hypidiomorphic.

This gabbroic diorite is virtually identical to the rock found in Columbian Fuel Corp., Strat. Test No. 6 (Gr-50) six miles to the east, and is a representative of the Raggedy Mountain Gabbro Group.

SHAMROCK OIL & GAS CO., 1 RUSK SW SW SW 1-6N-24W (Gr-56)

1550-1560'
Cuttings
Gr-56-1

Rhyolite porphyry...... Phenocrysts: plagioclase (16%), iron ore (2%); groundmass (82%): potash feldspar, quartz, feldspar alterations, chlorite, apatite, epidote. Highly sericitized and zeolitized plagioclase phenocrysts; some highly wormy and embayed phenocrysts may be perthite; numerous "infant" euhedral feldspars in groundmass; microlites of hairlike green chlorite(?), chlorite also as masses partly stained with hematite. Grain size: phenocrysts to 1.5 mm. Texture: porphyritic and spherulitic.

The "infant" feldspars in the groundmass suggest two generations of feldspar as discrete crystals, and a third environment of feldspar crystallization in the spherulitic groundmass. The rock is a representative of the Carlton Rhyolite Group.

R. M. LAURENCE INC., 1 AARON SE SE SE 25-6N-25W (Gr-57)

2960-2962'
Cuttings
Gr-57-1

Rhyolite tuff...... Groundmass, lithic fragments, and matrix (60%), quartz (13%), plagioclase (10%), perthite (7%), epidote (4%), iron ore (3%), chlorite (3%), sphene (tr.), sericite (tr.), apatite (tr.). Fragments of rhyolite in groundmass have been reconstituted and are virtually indistinguishable from the matrix; quartz detritus has some lithic groundmass clinging to them or, in a few instances, has well-defined concave surfaces; feldspars somewhat altered and stained with hematite; sphene associated with chlorite; epidote in masses of well-crystallized material; quartz veins are locally parallel to what appears to be bedding. Grain size: to 2 mm. Texture: clastic.

This tuff is similar to the rock found in the Taylor, 1 Fee (Bk-8) and helps in demonstrating the extrusive character of the Carlton Rhyolite Group in Greer County.

SHAMROCK OIL & GAS CORP., 1A FROST SE NW 24-6N-24W (Gr-58)

1434-1438'
Cuttings
Gr-58-1

Rhyolite porphyry...... Phenocrysts: plagioclase (12%), iron ore (3%); groundmass (85%): potash feldspar, quartz, chlorite, feldspar alterations, apatite, zircon. Albite phenocrysts altering to clay-sericite; hematite abundant in the groundmass as ragged dustlike particles associated with chlorite; groundmass is composed of a delicate intergrowth of quartz and feldspar, partly micrographic; chlorite is a blue-green variety and may represent a former femic mineral. Grain size: phenocrysts to 1.5 mm. Texture: porphyritic and felsophyric-micrographic.

A common rock of the Carlton Rhyolite Group.

SHAMROCK OIL & GAS CORP., 2 McDONALD NE SW SW 14-6N-24W (Gr-59)

1429-1433'
Cuttings
Gr-59-1

Rhyolite porphyry...... Phenocrysts: plagioclase (16%), iron ore (2%); groundmass (82%): potash feldspar, quartz, chlorite, feldspar alterations, calcite, leucoxene, epidote, apatite. Phenocrysts of albite contain unoriented epidote crystals; epidote also intergranular; groundmass is particularly spicular; chlorite may be pseudomorphous after a former mafic mineral in part; leucoxene and hematite replace portions of titaniferous magnetite grains. Grain size: phenocrysts to 2 mm. Texture: porphyritic and felsophyric-micrographic.

The rock in this well is similar to other examples of the Carlton Rhyolite Group found in nearby wells.

SHAMROCK OIL & GAS CORP., 1 BOYD SW SW 10-6N-24W (Gr-60)

1417-1424'
Cuttings
Gr-60-1

Rhyolite porphyry...... Phenocrysts: plagioclase (14%), sphene-leucoxene (2%); groundmass (84%): potash feldspar, quartz, chlorite, iron ore, feldspar alterations, calcite, apatite, zircon. Phenocrysts of sodic oligoclase contain unoriented sericite shreds; relict iron ore granules altering to sphene-leucoxene and hematite, associated with apatite and zircon; calcite replaces portions of the groundmass irregularly; minor delicate micrographic intergrowth in groundmass with spicular quartz. Grain size: phenocrysts to 1.5 mm. Texture: porphyritic and felsophyric.

A normal example of the Carlton Rhyolite Group.

JACKSON COUNTY

TENNESSEE GAS TRANS. CO., 1 KINNEY SW SW SW 23-4N-21W (Jk-1)

Olivine diabase...... Plagioclase (58%), pyroxene (16%), olivine (9%), iddingsite (7%), iron ore (6%), feldspar alterations (2%), chlorite (1%), biotite (1%), apatite (tr.). The majority of the plagioclase is extremely fresh but local alterations are present; olivine granules contain magnetite, biotite, and chlorite along cracks and at margins; biotite as primary shreds around magnetite and as fibrous alterations; the rock has a high content of olivine and iddingsite. Grain size: to 1.5 mm. Texture: ophitic to subophitic.

2191-2220'
Cuttings
Jk-1-1

Micrographic granite...... Perthite (64%), quartz (34%), chlorite (1%), iron ore (tr.), calcite (tr.), feldspar alterations (tr.), sphene (tr.), biotite (tr.), fluorite (tr.). Micrographic intergrowth well developed; biotite associated with chlorite in vein trends and as trends of discrete shreds disseminated through feldspars; sphene as minor granules around small titaniferous iron ore; a few large discrete quartz crystals are present; feldspars contain abundant hematite dust and minor alterations, both well disseminated. Grain size: 1.5 mm average. Texture: micrographic.

2270-2290'
Cuttings
Jk-1-2

The granite found in this well is an excellent example of a common type in the Wichita Granite Group. The olivine diabase represents a younger dike cutting the granite.

McCASLAND & WILCOX, 1 EDWARDS NW NW NE 9-3N-21W (Jk-4)

Andesite porphyry...... Plagioclase, chlorite, feldspar alterations, quartz, pyroxene, amphibole, sphene-leucoxene, iron ore, apatite. Altered laths of andesine with interstitial chlorite compose most of the rock; phenocrysts as zoned(?) pyroxene with minor amphibole are altering to a nearly colorless tremolitic amphibole; quartz appears to be secondary; secondary chlorite has anomolous brownish-violet interference colors; sphene-leucoxene in small granular masses; hematite stains feldspar and magnetite is in small granules. Grain size: 0.3 mm and less. Texture: porphyritic, intergranular, and pilotaxitic.

3660-3670'
Cuttings
Jk-4-1

Andesite porphyry...... Plagioclase, chlorite, feldspar alterations, pyroxene, epidote, sphene-leucoxene, amphibole, iron ore, apatite. Two distinct types of rock, one similar to the previously described sample and the other containing abundant andesine phenocrysts and lesser chlorite; chlorite occurs as partial to total pseudomorphs after pyroxene, both set in a cryptofelsic groundmass; groundmass high in feldspar alterations and iron ore; chlorite is a pennine type and is associated with minor sphene; epidote has been introduced into both rock types. Grain size: phenocrysts to 1 mm. Texture: porphyritic, pilotaxitic, and intergranular.

3710-3720'
Cuttings
Jk-4-2

Andesite porphyry...... Phenocrysts: plagioclase (24%), chlorite (8%); groundmass (62%): sphene (3%), epidote (3%), feldspar alterations, biotite, quartz, amphibole, pyroxene, apatite. Large phenocrysts of sodic andesine (An_{32}) are altered to sericite and clouded by zeolites; pennine-type chlorite as a partial to total pseudomorph after pyroxene, with sphene as a reaction byproduct; groundmass is cryptofelsic and appears to contain much finely divided biotite; local trends of quartz replace most of the groundmass but leaves the phenocrysts untouched; epidote well crystallized in veins and masses; several varieties of chlorite present; a colorless amphibole occurs with epidote. Photomicrograph, pl. XII-4. Grain size: phenocrysts to 1.5 mm. Texture: porphyritic and pilotaxitic.

3810-3820'
Cuttings
Jk-4-3

McCasland & Wilcox, 1 Edwards (cont.)

Andesite porphyry...... Plagioclase, chlorite, feldspar alterations, epidote, iron ore, biotite, quartz, sphene-leucoxene. One chip has a distinctly tuffaceous appearance that may be caused through vein replacement by quartz in intricate patterns; other chips are similar to the previously described sample; the thin section is too thick and mineral boundaries are indistinct; epidote and chlorite occur as pseudomorphs after a former mafic mineral; iron ore as dusty particles and as stain; plagioclase is turbid but appears to be andesine. Grain size: phenocrysts to 1.2 mm. Texture: porphyritic and pilotaxitic.

3920-3930'
Cuttings
Jk-4-4

Andesite porphyry...... Plagioclase, feldspar alterations, biotite, chlorite, iron ore, amphibole, epidote, quartz, sphene-leucoxene, apatite. Phenocrysts of andesine are strongly to mildly zoned; groundmass is stained with hematite and appears to be composed largely of altered feldspar, with locally well-developed trachytic lineation; biotite and chlorite are both found as pseudomorphs after a mafic mineral; epidote in secondary masses associated with minor chlorite, in amygdules. Grain size: phenocrysts to 0.6 mm. Texture: porphyritic and pilotaxitic-trachytic.

4110-4120'
Cuttings
Jk-4-5

Altered andesite porphyry...... Feldspar alterations, plagioclase, quartz, iron ore, sphene-leucoxene, chlorite, biotite, calcite, epidote, microcline(?), apatite. A highly altered rock of andesitic origin; feldspars replaced in part by sericite and zeolites, even the least-altered material being turbid; sphene-leucoxene occurs as granular masses of irregular shape; iron ore granules common but small; microcline(?) as a clear vein mineral; quartz replaces groundmass in linear trends; biotite and chlorite both comparatively rare. Grain size: phenocrysts to 0.6 mm. Texture: porphyritic and relict trachytic.

4220-4230'
Cuttings
Jk-4-6

Altered andesite porphyry...... Feldspar alterations, quartz, chlorite, plagioclase, iron ore, sphene-leucoxene, apatite. Relict patches of less altered material have high chlorite content; groundmass is essentially feldspar and alterations, both stained with hematite; alterations are mostly sericite with some zeolites; quartz replaces portions of the groundmass in a chertose mosaic; no relict mafic phenocrysts noted. Grain size: phenocrysts to 0.4 mm. Texture: porphyritic and relict trachytic.

4270-4280'
Cuttings
Jk-4-7

Silicified and altered andesite porphyry...... Plagioclase alterations, quartz, sericite, plagioclase, chlorite, iron ore, sphene-leucoxene, riebeckite, calcite, apatite. Two chips are completely replaced by quartz and sericite with small patches of less altered material; iron ore, chlorite, and small riebeckite crystals occur with the quartz and sericite; less altered rocks contain highly altered plagioclase and some poorly defined phenocrysts. Grain size: relict phenocrysts to 0.4 mm. Texture: porphyritic, xenomorphic, and relict trachytic.

4413'
Cuttings
Jk-4-8

The sequence of intermediate lavas is the thickest penetration of the Navajoe Mountain Basalt-Spilite Group south of the Wichita Mountains. The progressive alteration of the andesites with depth may indicate the proximity of a granitic intrusion, a situation similar to that found in the Lippert, 1 Howard (Jk-7) a few miles to the east. The presence of riebeckite in the altering products strongly suggests a source from solutions associated with the Wichita granites. There is evidence for only the lowest grades of metamorphism, perhaps the zeolite facies. The andesitic character of these lavas is unique, as it has not been found in other wells.

For chemical analysis of composite cuttings from 3,620 to 3,770 feet, see table 18.

RUSSELL, 1 DANIEL   NW NE SE 13-3N-20W   (Jk-6)

Granite porphyry...... Perthite, quartz, plagioclase, iron ore, biotite, chlorite, feldspar alterations, apatite, zircon. Large perthite crystals are slightly altered and clouded with hematite dust; biotite is replaced by magnetite and is altered to chlorite; albite contains minor sericite flakes; zircon and apatite associated with iron ore. Grain size: to 3 mm. Texture: hypidiomorphic and porphyritic.
1300-1315'
Cuttings
Jk-6-1

This granite is near the contact of the Navajoe Mountain Basalt-Spilite Group with the Wichita Granite Group and is possibly the same granite that intrudes the Lippert, 1 Howard (Jk-7) a few miles to the east

LIPPERT, 1 HOWARD   SW NW 10-3N-19W   (Jk-7)

Basic hornfels...... Plagioclase (33%), pyroxene (27%), iron ore (17%), hornblende (16%), biotite (7%), apatite (tr.). A slight schistosity is noted in the epidote orientation; biotite encloses other constituent minerals in a sieve texture, and is not parallel to the general lineation; plagioclase appears to be intermediate in composition but twinning is absent or poorly defined; magnetite as small discrete grains of slightly irregular shape; the areas containing abundant hornblende are poor in pyroxene; biotite replaces hornblende in one chip. Grain size: to 0.7 mm, 0.1 mm average. Texture: granoblastic to faintly schistose.
938-962'
Cuttings
Jk-7-1

Micrographic granite porphyry...... Perthite (61%), quartz (29%), iron ore (4%), plagioclase (3%), hornblende (1%), feldspar alterations (tr.), biotite (tr.), sphene (tr.), apatite (tr.), zircon (tr.). Perthite phenocrysts are well defined, showing Carlsbad twins and containing small hornblende inclusions; feldspars slightly turbid; quartz-feldspar intergrowth delicate; sphene occurs as small granules around titaniferous magnetite; hornblende has a small amount of reddish alteration biotite in association. Photomicrograph, pl. XI-3. Grain size: to 2 mm. Texture: porphyritic and micrographic.
984-991'
Cuttings
Jk-7-2

Basic hornfels cut by granite...... Plagioclase, perthite, quartz, hornblende, biotite, iron ore, epidote, chlorite, feldspar alterations, apatite. These chips show contacts between granite and the basic hornfels; the contact is generally well defined and sharp; the free plagioclase content of the granite is much higher than was noted in previous samples, and all micrographic intergrowth has disappeared; the stable mafic mineral in the hornfels is biotite but near the contact it has been converted to hornblende; plagioclase highly altered; pyroxene is less common near granite contact; feldspar is clouded in the granite but clear in the hornfels. Grain size: to 2 mm in granite, 0.1 to 0.05 mm in hornfels. Photomicrograph, pl. XII-6. Texture: hypidiomorphic in granite, granoblastic in hornfels.
1004-1011'
Cuttings
Jk-7-3

Basic hornfels...... Pyroxene (47%), plagioclase (37%), iron ore (13%), biotite (2%), quartz (1%), sphene (tr.). A rapid variation in grain size and mineralogic percentages characterize this hornfels; iron ore locally approaches dust size and has a cloudlike appearance; biotite is reddish brown to greenish brown; sphene in small granules associated with epidote; quartz is found as a vein and as a replacement near the vein; epidote contains iron ore granules. Grain size: 0.01 to 0.1 mm. Texture: granoblastic.
1094-1100'
Cuttings
Jk-7-4

Basic hornfels-granite contact...... Perthite, quartz, plagioclase, iron ore, hornblende, biotite, feldspar alterations, apatite, zircon. Magnetite concentrated along the contact; granite contains clouded patch perthite and is quartz poor; the hornfels contains plagioclase, biotite, hornblende, and minor apatite and iron ore; hornblende in hornfels has poorly developed sieved texture and is oriented parallel to the granite contact. Grain size: 1.5 mm in granite, 0.15 mm in hornfels. Texture: granoblastic in hornfels, hypidiomorphic in granite.
1465-1472'
Cuttings
Jk-7-5

Basic hornfels-granite contact...... Plagioclase, quartz, perthite, hornblende, augite, iron ore, biotite, sphene, calcite, feldspar alterations, apatite, zircon. Hornblende is stable mafic mineral in the hornfels but is converted to augite near the granite contact; quartz metacrysts occur in the hornfels; granite contains perthite with quartz and free plagioclase; free sphene occurs in the hornfels and as a rim around titaniferous magnetite in the granite. Grain size: 1.7 mm in granite, 0.15 average in hornfels. Texture: granoblastic in hornfels, hypidiomorphic in granite.
1488-1500'
Cuttings
Jk-7-6

This well penetrated hornfels derived from a basic rock, probably in the Navajoe Mountain Basalt-Spilite Group. It is permeated by a granite of the Wichita Granite Group. The samples from this well are unfortunately incomplete and many important intervals have no samples. The abundance of chips containing both hornfels and granite in contact strongly suggests the rock is approaching a migmatite. The metamorphic agent responsible for the hornfels is the Wichita granite.

BURKE-GREIS OIL CORP., 1 WRIGHT   NW SW 31-3N-19W   (Jk-8)

Granite...... Microcline perthite, quartz, plagioclase, chlorite, iron ore, feldspar alterations, apatite. Almost no accessory minerals are noted, as approximately 99 percent of the rock is quartz and feldspar; the relative coarseness of the rock makes percentage determination impossible from cutting chips; oligoclase abundant as large crystals; microcline twinning well defined in some chips; feldspar is slightly turbid. Grain size: 3 mm+. Texture: hypidiomorphic.
1270-1278'
Cuttings
Jk-8-1

The presence of microcline perthite makes this a slightly unusual example of the Wichita Granite Group.

GENE BURKE, 1 ESTES   SW SW NE 34-3N-19W   (Jk-9)

Meta-graywacke...... Quartz, biotite, feldspar, iron ore, feldspar alterations, apatite. Chertose quartz and small reddish-green biotite flakes act as a matrix for fine-grained clastic particles; magnetite as inclusions in biotite; apatite as an inclusion in quartz. Grain size: 0.15 mm and smaller. Texture: clastic-crystalloblastic.
830-840'
Cuttings
Jk-9-1

Meta-graywacke and argillite...... Quartz (31%), biotite (45%), feldspar (23%), chlorite (1%), feldspar alterations, iron ore. Similar to the previous sample, with addition of fine-grained argillite; chips of argillite are variable in biotite content; the meta-graywacke chips have detrital fine quartz and feldspar cemented by a quartz mosaic containing crystalloblastic biotite shreds. Grain size: 0.15 mm and smaller. Texture: clastic-crystalloblastic.
930-940'
Cuttings
Jk-9-2

Meta-graywacke...... Detrital grains (40%): quartz (12%), feldspar (25%), lithic fragments (3%); matrix (60%): chlorite, quartz, biotite, feldspar, zircon, iron ore. This sample is coarser than those previously described and is a very fine-grained meta-graywacke; biotite is crystalloblastic in a chertose quartz matrix; chlorite occurs as a pseudomorph after biotite; minor vein quartz; feldspars sparingly altered to sericite and minor clays; magnetite and hematite occur in biotite flakes. Grain size: 0.2 mm average. Texture: clastic-crystalloblastic.
990-1000'
Cuttings
Jk-9-3

Silicified metasediment...... Quartz (46%), feldspar (32%), chlorite (9%), biotite (8%), iron ore (2%), feldspar alterations (1%), sphene (1%).
1060-1070' Cuttings Jk-9-4
One chip is a normal meta-graywacke, others are a granoblastic mosaic of quartz containing areas and linear trends of feldspar, slightly altered and stained with hematite; small amounts of chlorite and iron ore are present in the silicified chips; chlorite associated with feldspar. Grain size: 0.1 to 0.02 mm. Texture: granoblastic.

The rock encountered in this well is an example of the finer grained varieties of the Tillman Metasedimentary Group. The silicification does not appear to be unusual and is noted also in the McCasland & Wilcox, 1 Edwards (Jk-4).

GULF OIL CORP., 1 INKLEBARGER SW SW SW 3-1N-20W (Jk-13)

Rhyolite porphyry hornfels...... Albite phenocrysts (5%); groundmass (95%): potash feldspar, quartz, hornblende, iron ore, biotite, chalcedony, calcite, chlorite, zircon, apatite.
2135-2136' Cuttings Jk-13-1
Relict phenocrysts of albite (An_4) are set in a groundmass of granoblastic quartz, feldspar, and hornblende; the hornblende shows well-defined sieve structure and is present both as actinolitic and as a common variety; one chip has a high hematite content and another chip has a very fine-grained groundmass with chalcedony replacing former phenocrysts. Photomicrograph, pl. IX-5. Grain size: phenocrysts to 1 mm+. Texture: relict porphyritic and granoblastic.

This rock is an example of the metamorphism in rocks of the Carlton Rhyolite Group on the Altus dome. This rhyolite is the closest to granite of three rhyolites penetrated in the dome area and shows the most complete reconstitution. The metamorphism is caused by the intrusion of Wichita granites found in wells Jk-14, Jk-15, and Jk-16, located to the west and southwest.

GULF OIL CORP., 1 LIZZIE SE SE NW 4-1N-20W (Jk-14)

Microgranite porphyry...... Potash feldspar, quartz, plagioclase, iron ore, biotite, calcite, feldspar alterations, apatite, hornblende, zircon, sphene-leucoxene.
2558' Cuttings Jk-14-1
The groundmass is a rather fine interlocking mosaic of quartz and locally clouded feldspar; feldspar phenocrysts are clouded and contain hematite dust and are generally rounded; sphene-leucoxene associated with chlorite alterations. Grain size: groundmass 0.2 mm, phenocrysts to 2 mm. Texture: porphyritic and xenomorphic.

All granites in the Altus dome area are fine grained and porphyritic. Their close geographic association with rhyolites suggests that they represent the marginal phase of a Wichita granite intruded into the rhyolite.

JOHN BAIDGER, 1 ELLIOT NE NE 5-1N-20W (Jk-15)

Microgranite porphyry...... Potash feldspar, quartz, plagioclase, iron ore, chlorite, calcite, amphibole, sphene-leucoxene, biotite, apatite, zircon.
2685-2697' Cuttings Jk-15-1
Feldspar phenocrysts are clouded and rounded; the groundmass is a quartz-feldspar mosaic containing mildly pleochroic hornblende as an intergranular mineral associated with biotite and chlorite; sphene-leucoxene and calcite associated in skeletal crystals; some quartz has incipient micrographic intergrowth. Grain size: groundmass 0.3 mm, phenocrysts to 1.5 mm. Texture: porphyritic and xenomorphic.

This rock is similar to that found in the Gulf, 1 Lizzie (Jk-14) and is interpreted as a marginal phase of the Wichita Granite Group.

GULF OIL CORP., 2 FOWLER NE NE SW 9-1N-20W (Jk-16)

Micrographic microgranite...... Potash feldspar, quartz, plagioclase, iron ore, chlorite, calcite, biotite, feldspar alterations, apatite, zircon.
2723' Cuttings Jk-16-1
Very small cutting chips; micrographic intergrowth delicate but well defined; hematite veins common; titaniferous magnetite is associated with sphene-leucoxene granules; chlorite is abundant; biotite appears to be replacing an amphibole. Grain size: 0.8 mm. Texture: micrographic.

This is the most nearly normal granite found in the Altus dome area but the grain size is less than that of the average granite of the Wichita Mountains. The rock is interpreted as a chilled phase of the Wichita Granite Group.

GYPSY OIL CO., 1 JOHNSON NW SW SE 11-1N-20W (Jk-17)

Silicified rhyolite porphyry...... Plagioclase phenocrysts (12%), groundmass (88%), quartz, potash feldspar, iron ore, chlorite, feldspar alterations, calcite, sphene-leucoxene, apatite, zircon.
1978-1982' Cuttings Jk-17-1
Plagioclase phenocrysts altered and contain much heamtite dust; groundmass is mainly chertose quartz with feldspar relicts and abundant chlorite; calcite as a vein mineral. Grain size: phenocrysts to 2 mm. Texture: porphyritic and xenomorphic.

The silicification of this rhyolite of the Carlton Rhyolite Group is probably related to the granite intrusions found in nearby wells. The rhyolite, being stratigraphically high with regard to other basement rocks, is probably preserved as a former synclinal relict now occupying the highest structural part of the Altus dome.

SUN OIL CO., 1 WILSON NE NE SE 23-1N-20W (Jk-18)

Metabasalt porphyry...... Plagioclase, biotite, tremolite, quartz, chlorite, iron ore, sphene, epidote, feldspar alterations, calcite, pyrite, apatite.
3710-3727' Cuttings Jk-18-1
Phenocrysts of undetermined calcic plagioclase contain crystalloblastic tremolite and sericite with minor inclusions of iron ore, chlorite, and quartz; the groundmass has been reduced to chertose quartz with crystalloblastic biotite, tremolite, sericite, and iron ore, sphene, and apatite; chlorite represents a retrograde mineral after tremolite. Photomicrograph, pl. XII-5. Grain size: phenocrysts to 2.5 mm. Texture: relict porphyritic and crystalloblastic.

The metamorphism shown by this example of the Navajoe Mountain Basalt-Spilite Group is comparable to the grade of metamorphism shown in the meta-graywackes to the east in Tillman County.

GUTOWSKI, 1 BOOKER NW NW NW 33-2N-18W (Jk-22)

Meta-graywacke...... Quartz, feldspar, lithic fragments, biotite, chlorite, calcite, iron ore, sphene-leucoxene, apatite.
840-848' Cuttings Jk-22-1
Clastic fragments are set in a chertose quartz matrix containing crystalloblastic biotite; lithic detritus includes metamerts, schists, quartzite, fine hornfels, and fragments of granitic origin; large quartz detritus is faintly strained; feldspars appear to be mostly plagioclase with minor alterations; sorting is poor and fragments are subrounded to angular; minor vein quartz is present. Grain size: to 1.5 mm. Texture: clastic-granoblastic.

Meta-graywacke...... Quartz, feldspar, lithic fragments, biotite, chlorite, iron ore, sphene-leucoxene, apatite, feldspar alterations, zircon. Similar to the previous sample; chlorite as cavitylike filling and in linear trends; biotite concentrated at the margins of detrital grains; fragments show no marginal suturing. Grain size: to 0.8 mm. Texture: clastic-granoblastic.

880-887'
Cuttings
Jk-22-2

Meta-graywacke...... Detrital grains (70%): quartz (25%), feldspar (40%), lithic fragments (5%); matrix (30%): quartz, feldspar, chlorite, biotite, epidote, sphene-leucoxene, iron ore. A finer grained rock than the previous samples; biotite is in small flakes; chlorite is a pennine type; detritus boundaries are less well defined and some suturing is noted; lithic fragments are less common than in previous intervals; detrital grains are rarely in contact but are separated by the chertose matrix. Grain size: to 0.3 mm. Texture: clastic-granoblastic.

940-948'
Cuttings
Jk-22-3

Meta-graywacke and meta-graywacke silt...... Quartz, feldspar, biotite, lithic fragments, chlorite, calcite, iron ore, hornblende, sphene-leucoxene, apatite, zircon. Lithic fragments are sparse and were not recognized in the finer grained chips; finer grained chips contain much more biotite; fragments are subrounded to angular, with angular fragments dominating; matrix is composed of chertose quartz and crystalloblastic biotite. Grain size: to 0.15 mm. Texture: clastic-granoblastic.

990-997'
Cuttings
Jk-22-4

Meta-graywacke...... Quartz, feldspar, lithic fragments, biotite, chlorite, iron ore, sphene-leucoxene, apatite. Rock and mineral fragments are set in a matrix of chertose quartz and small flakes of crystalloblastic biotite with associated chlorite; biotite content is less than in previous samples; some detrital quartz is strained; vague lineation is apparent in the matrix micas; lithic fragments are mostly cherts and granites; detrital grains are rarely in contact but are separated by the reconstituted matrix. Grain size: 0.2 mm average. Texture: clastic-granoblastic.

1004-1012'
Cuttings
Jk-22-5

This well is an excellent example of the Tillman Metasedimentary Group. The variation in grain size, approaching an argillite, and the grade of metamorphism are typical. The diverse mineral and lithic detrital grains are essentially floating in the reconstituted matrix, originally a clay.

SCHAFFER DRLG. CO., 1 HOWARD   SE SE SW 9-2N-19W   (Jk-25)

Bedded meta-chert...... Quartz, iron ore, sericite, unidentified acicular inclusions. A fine-grained and partly laminated chert, containing numerous unoriented quartz veins; hematite occurs as ragged, irregular grains and hairlike particles throughout the rock, with local concentrations along bedding planes; sericite as minor small discrete shreds; minute hairlike acicular inclusions occur in quartz; hematite percentage variable. Grain size: 0.01 mm average. Texture: crystalloblastic.

900-910
Cuttings
Jk-25-1

Bedded meta-chert...... Quartz, chlorite-biotite, iron ore. This is a composite of two thin sections from the same interval, one section of reddish chips, the other from greenish chips; both are partly laminated fine-grained chert; the greenish chips contain abundant chlorite and biotite in tiny flakes; quartz veins leave a mica-impoverished zone; ragged hematite dust present with the micas; reddish chips have more hematite, concentrated in layers; apparent brecciation occurs in the reddish chips; radiolarians(?) locally present. Grain size: 0.01 mm average. Texture: crystalloblastic.

940-950'
Cuttings
Jk-25-2&3

The rock in this well is a reconstituted bedded chert of the Tillman Metasedimentary Group. Reconstitution of argillaceous constituents has produced sericite, biotite, and hematite. It is the only example of basement-rock chert so far found in southern Oklahoma.

SCHAFFER DRLG. CO., 1 WRIGHT   NE NE SE 31-3N-19W   (Jk-26)

Granite porphry...... Microcline perthite, quartz, plagioclase, biotite, iron ore, hornblende, chlorite, feldspar alterations, leucoxene, sphene. Large string-type perthite phenocrysts contain cores of albite; biotite interlayered with iron ore and altering to chlorite; minor well-crystallized hornblende; plagioclase more highly altered than perthite. Grain size: phenocrysts to 3.5 mm. Texture: porphyritic and hypidiomorphic.

1175-1188'
Cuttings
Jk-26-1

The relatively abundant mafic minerals and the presence of microcline in the perthite make this a rather unusual rock in the Wichita Granite Group.

GYPSY OIL CO., 1 KELLY   NE NE NE 10-1N-20W   (Jk-27)

Silicified rhyolite porphyry...... Phenocrysts: perthite (8%), plagioclase (3%), quartz (2%); groundmass (87%): iron ore, chlorite, calcite, feldspar alterations, sphene-leucoxene, zircon, apatite. Feldspar and minor quartz phenocrysts are set in a highly chertose groundmass containing abundant chlorite; lineation indicates relict flow bands; feldspar occurs as a minor vein mineral; iron ore and sphene-leucoxene associated with chlorite; quartz phenocrysts have been marginally reconstituted by groundmass silica. Grain size: phenocrysts to 1.5 mm. Texture: porphyritic and xenomorphic.

1980-2020'
Cuttings
Jk-27-1

This silicified example of the Carlton Rhyolite Group is believed to have been altered by the granite intrusions of the immediate (Altus dome) area. In the lower part of the hole a diabasic intrusion into rhyolite was penetrated.

JEFFERSON COUNTY

CITIES SERVICE OIL CO., 1 GARDNER — SE SE NE 36-5S-9W — (Jf-1)

3650-3660' Cuttings Jf-1-1

Micrographic granite porphyry...... Perthite (57%), quartz (27%), albite (6%), iron ore (4%), chlorite (3%), sphene (tr.), epidote (tr.), zircon (tr.), apatite (tr.). Quartz exclusively in micrographic intergrowth; perthite is turbid with alterations and included hematite dust; feldspar phenocrysts contain small epidote granules; chlorite is a pennine type and contains minor interlayered sphene; sphene also occurs as minor granules around titaniferous magnetite. Grain size: 1.5 mm average. Texture: porphyritic and micrographic.

This well penetrated rock of the Wichita Granite Group. Located on the Muenster-Waurika arch, it is the most southerly of the Wichita-type granites in Oklahoma.

L. D. McMILLAN, 1 STANLEY — NW SE SE 30-5S-8W — (Jf-2)

3570-3580' Cuttings Jf-2-1

Rhyolite porphyry...... Phenocrysts: perthite (17%), albite (8%), iron ore (2%); groundmass (73%): quartz, chlorite, feldspar alterations, calcite, sphene-leucoxene, apatite, zircon. Delicate and feathery but well-defined micrographic intergrowth is partly radial; perthite phenocrysts are embayed whereas smaller albite crystals are euhedral; chlorite is associated with minor sphene-leucoxene and is locally stained by hematite; hematite dust is abundant in feldspars, producing a deep-red color; apatite as numerous slender needles. Grain size: phenocrysts to 1.8 mm. Texture: porphyritic and micrographic.

The rhyolite is interpreted as a coarser than normal example of the Carlton Rhyolite Group. It is similar to that in the Texhoma, 1 King (Jf-3) but is quite distinct from the normal Wichita granite of the area such as was penetrated in the Cities Service, 1 Gardner (Jf-1).

TEXHOMA PROD. CO., 1 KING — NE NW SW 30-5S-8W — (Jf-3)

3765' Cuttings Jf-3-1

Rhyolite porphyry...... Phenocrysts: plagioclase (16%), iron ore (3%), quartz (1%); groundmass (76%): epidote (4%), potash feldspar, chlorite, feldspar alterations, apatite, zircon. Delicate feathery spherulites contain oriented rods of iron ore; some spherulites have plagioclase phenocryst cores; plagioclase contains clouding alterations and hematite dust; epidote as fillings in phenocryst embayments and as well-crystallized inter-spherulite mineral; one chip approaches granitic texture. Grain size: phenocrysts to 2 mm. Texture: porphyritic, spherulitic, and micrographic.

The rhyolite is placed in the Carlton Rhyolite Group as a coarser, perhaps intrusive, rock. There is a possibility that this rock represents a chilled phase of a normal granite but certain petrographic features are unlike the chilled phases of granites found in outcrop in the Wichita Mountains.

BRIDWELL OIL CO., 1 SMART — NW SE 13-7S-6W — (Jf-6)

2201-2220' Cuttings Jf-6-1

Granite porphyry...... Quartz (30%), perthite (26%), microcline (24%), plagioclase (10%), chlorite (4%), feldspar alterations (4%), biotite (2%), iron ore (tr.), leucoxene (tr.), epidote (tr.), apatite (tr.), zircon (tr.). The rock is coarse and the mineral percentages differ considerably from chip to chip; biotite, epidote, and sericite masses enclosed in feldspar; biotite also as masses associated with chlorite and in secondary granitic veins; perthite is a patch type; quartz crystals are strained. Grain size: 5 mm+. Texture: porphyritic and hypidiomorphic.

Bridwell Oil Co., 1 Smart (cont.)

The coarseness and presence of microcline and free plagioclase make this rock a good example of the Eastern Arbuckle Province. This is substantiated by the Sinclair, 1 Peterson (Jf-15) a few miles to the northwest and by several granite tests in Texas that are definitely not allied to the Wichita granites.

THE TEXAS CO., 1 SMART — NE SE NW 14-7S-6W — (Jf-8)

2340-2367' Cuttings Jf-8-1

Biotite schist...... Quartz, feldspar, biotite, chlorite, hematite, garnet, feldspar alterations. Biotite altering to chlorite with hematite spots formed in the chlorite; feldspars somewhat altered to sericite; hematite is an irregular intergranular stain; some large strained quartz is present; garnet is a minor mineral with irregular form; biotite shows good alignment. Grain size: 0.3 mm average. Texture: lepidoblastic.

This schist represents a higher grade of metamorphism than is found in the Tillman Metasedimentary Group. The close proximity of Tishomingo-type granite in the Bridwell, 1 Smart and the presence of rocks of similar grade to the south in Texas strongly suggest that the rock is associated, perhaps as an inclusion, with granite of the Eastern Arbuckle Province. It is the only penetration of a metamorphic rock in the Eastern Arbuckle Province, although similar rocks are known from outcrop in the Tishomingo segment of the Arbuckle Mountains.

MAGNOLIA PETRO. CO., 1 GULF FEE — C NE SW 22-3S-5W — (Jf-14)

6430-6431' Core Jf-14-1

Perlitic rhyolite porphyry...... Phenocrysts: quartz (4%), sphene-leucoxene (3%), iron ore (2%); groundmass (91%): feldspar, siderite, feldspar alterations, chlorite, apatite, zircon. Feldspar phenocrysts have been replaced by clay-sericite masses; small quartz phenocrysts are rounded and some are the cores of perlites; perlite cracks control devitrification; siderite replaces portions of the groundmass and appears slightly limonitic; chlorite is rare; perlite cracks outlined by hematite; thin quartz veins present. Grain size: phenocrysts to 1 mm. Texture: porphyritic and perlitic.

The perlitic cracks demonstrate the extrusive origin for this member of the Carlton Rhyolite Group. The well is important geographically in the subsurface mapping of the Carlton Group, as it is between two widely spaced control wells along the Wichita-Criner Hills axis.

SINCLAIR, 1 PETERSON — NW SW NE 32-6S-6W — (Jf-15)

3890-3910' Cuttings Jf-15-1

Granite...... Microcline perthite, quartz, plagioclase, chlorite, iron ore, biotite, feldspar alterations, epidote, calcite, sphene-leucoxene, zircon, apatite. Cataclastic effects are marked with straining and granulation of quartz, mortared boundaries, and bending of plagioclase twins; perthite is both a string and patch type; plagioclase is badly altered, containing sericite flakes and disseminated hematite; one chip has been reduced to the appearance of aplite, with conspicuous lineation and small calcite veinlets; epidote, chlorite, and iron ore are associated with sphene-leucoxene. Grain size: 3 mm+. Texture: cataclastic and hypidiomorphic.

4200-4220' Cuttings Jf-15-2

Granite...... Microcline perthite, quartz, plagioclase, chlorite, iron ore, biotite, feldspar alterations, sphene-leucoxene, calcite, zircon, apatite. Cataclastic effects are marked as in the previous interval; veinlets of hematite cut feldspars; biotite and chlorite are associated in linear trends with iron ore, zircon,and sphene-leucoxene; some feldspars are faintly zoned; zircon appears partly metamict. Grain size: 3.5 mm+. Texture: cataclastic and hypidiomorphic.

Sinclair, 1 Peterson (cont.)

4510-4530'
Cuttings
Jf-15-3

Granite...... Microcline perthite, plagioclase, quartz, biotite, epidote, chlorite, feldspar alterations, iron ore, calcite, zircon. Cataclastic effects are marked but incipient metamorphism is also striking; large sericite flakes are developed in plagioclase with numerous well-formed epidote crystals; new biotite, associated with masses of epidote, in deep olive-green crystals; hematite is in veinlets and disseminated flecks; part of the epidote has the anomalous interference colors of clinozoisite. Grain size: 4.5 mm+. Texture: cataclastic, incipient crystalloblastic, and hypidiomorphic.

4663-4666'
Core
Jf-15-4

Granite...... Microcline perthite (37%), quartz (39%), plagioclase (16%), chlorite (2%), biotite (2%), feldspar alterations (2%), epidote (1%), sphene (1%), iron ore (tr.), hornblende (tr.), calcite (tr.), apatite (tr.), zircon (tr.). Quartz is strained and has granulose character; masses of secondary biotite, epidote, and sphene are in a linear intergranular position; biotite altered to chlorite; sphene is in discrete crystals and granular masses associated with biotite and as rims around titaniferous magnetite; plagioclase is much more altered than microcline and contains numerous epidote crystals and sericite as a fibrous mat or as well-formed discrete flakes. Photomicrograph, pl. XVI-2. Grain size: to 15 mm. Texture: cataclastic, incipient crystalloblastic, and hypidiomorphic.

This is an excellent example of the rocks of the Eastern Arbuckle Province along the Muenster arch in southern Jefferson County. The incipient metamorphic effects increase downward and the cataclastic features are marked throughout, both of these characteristics being typical of the granite found in the eastern Arbuckle Mountain area.

Feldspar from the core at 4,663-4,666 feet is dated by Rb/Sr at 1,050 million years (table 4), the youngest known rock of the Eastern Arbuckle Province.

MACK OIL CO., 1 COX NW SE NE 35-7S-6W (Jf-16)

5760-5842'
Cuttings
Jf-16-1

Granite...... Microcline perthite, plagioclase, quartz, biotite, chlorite, feldspar alterations, sphene, epidote, leucoxene, iron ore, calcite, apatite, zircon. Perthitic microcline is generally fresh while the sodic oligoclase is clouded with alterations; sericite flakes and euhedral epidote are common near the cores of some plagioclases; olive-brown biotite is altered to a strongly pleochroic chlorite containing attendant leucoxene, sphene granules, epidote, and hematite; quartz is in part highly strained; some plagioclase twins are bent and broken; sphene is also present in larger primary crystals; secondary biotite and chlorite forms bundles of shreds penetrating feldspars in veinlike trends. Grain size: greater than 5.8 mm. Texture: hypidiomorphic.

This is one of the four control wells in Jefferson County that penetrate rocks of the Eastern Arbuckle Province, and is the only control well on the downthrown side of the fault on the south side of the Muenster arch. The cataclastic imprint and the secondary growth of minerals is typical of rocks in this province.

JOHNSTON COUNTY

ATLANTIC OIL CO., CORE HOLE No. 2 NE NW 36-4S-8E (Jn-6)

348'
Core
Jn-6-1

Altered hornblende diorite...... Amphibole, iron ore, calcite, clay alterations, chlorite, plagioclase, granitic vein. A poor thin section of an extremely altered rock; much of the rock has been destroyed during preparation and textural relationships are unknown; one large hornblende crystal contains poikilitically enclosed quartz, clay, plagioclase, and unoriented hornblende; clay replaces much of the andesine (An_{37}); a granitic vein of quartz and microcline traverses the core; most plagioclase is intergranular. Grain size: to 7 mm. Texture: questionable.

This well is interpreted as penetrating a hornblende-rich segregation in a normal hornblende diorite of the Eastern Arbuckle Province. This type of segregation is common in the diorites cutting the granites in the Phillips, 1 Matoy (Br-2).

HAYNES OIL CO., 1 OVERTON SE SE SE 6-5S-8E (Jn-7)

Slush pit
Cuttings
Jn-7-1

Diabase...... Plagioclase, pyroxene, iron ore, feldspar alterations, chlorite, amphibole, biotite, quartz, apatite. Labradorite is altering to sericite and zeolites; pyroxene is in well-formed crystals and masses of small aggregate crystals; uralitic hornblende replaces portions of the pyroxene; chlorite replaces primary biotite and pyroxene; one mass of hematite-stained mica is similar to iddingsite. Grain size: to 0.8 mm. Texture: subophitic to intergranular.

These samples came from the slush pit at the well site and are from an unknown depth. They were collected by the Socony Mobil Oil Co. The rock is interpreted as a diabase dike intruded into granite, not obtained, of the Eastern Arbuckle Province.

NYOLKA, 1 HOOD NE NE NE 7-5S-8E (Jn-13)

Slush pit
Cuttings
Jn-13-1

Granite...... Microcline, plagioclase, quartz, biotite, chlorite, feldspar alterations, calcite, iron ore, apatite, zircon. Mineralogic percentages differ considerably from chip to chip; the rock is relatively poor in femic minerals in comparison to the usual rock of this type; minor myrmekitic intergrowth locally developed; feldspars are altered in a mottled pattern; biotite contains interlayered alteration chlorite and attendant iron ore. Grain size: to 3 mm. Texture: hypidiomorphic.

A rock from the Eastern Arbuckle Province, somewhat poor in femic minerals.

MARS, 1 CRAVAT SE NE NW 9-4S-7E (Jn-14)

Slush pit
Cuttings
Jn-14-1

Granite...... Microcline, plagioclase, quartz, biotite, hornblende, feldspar alterations, calcite, iron ore, apatite, zircon. Microcline is partly in a string type perthite and also occurs as large crystals with poikilitically enclosed quartz, plagioclase, and unoriented microcline; primary hornblende and biotite are altering to chlorite and minor associated iron ore; hematite as a minor stain on the feldspars; feldspars altering to both clay and sericite. Grain size: to 5 mm. Texture: hypidiomorphic.

A typical granite found in Johnston County and an example of the Eastern Arbuckle Province rocks.

FAIN-PORTER DRLG. CO., 1 PETERS S½ NE NE 34-2S-8E (Jn-15)

Granite...... Microcline, plagioclase, quartz, biotite, hornblende, epidote, iron ore, feldspar alterations, chlorite, sphene, zircon, apatite.
90-100'
Cuttings
Jn-15-1
Feldspars are clear to mottled with alterations, alteration particularly marked near the core of large plagioclase crystals; biotite and hornblende appear crystalloblastic and show excellent sieve structure; grain size is irregular; quartz crystals are small and are slightly strained; epidote is well crystallized and associated with biotite and hornblende; small amounts of myrmekitic intergrowth locally developed. Grain size: to 3 mm. Texture: hypidiomorphic and crystalloblastic.

Granite...... Microcline, plagioclase, quartz, biotite, hornblende, feldspar alterations, epidote, iron ore, sphene, calcite, chlorite, apatite, zircon.
380-390'
Cuttings
Jn-15-2
Large biotite and hornblende crystals have a well-defined sieve structure and are associated with epidote, sphene, and iron ore; feldspars are irregularly altered and show some zoning; calcite as irregular veinlets; large sericite flakes locally developed; chlorite as small shreds after biotite. Grain size: to 3 mm but irregular. Texture: hypidiomorphic and crystalloblastic.

Granite...... Microcline, plagioclase, quartz, biotite, hornblende, iron ore, epidote, feldspar alterations, sphene, calcite, chlorite, apatite, zircon.
550-560'
Cuttings
Jn-15-3
Similar to previous samples; both biotite and hornblende have a sieve structure; feldspar alterations are irregular and in part are veinlike; grain size variable; epidote is found with anomalous interference colors and as a normal variety; zircon and apatite are both discrete and associated with iron ore. Grain size to 2 mm but variable. Texture: hypidiomorphic and crystalloblastic.

Granite...... Microcline, plagioclase, quartz, biotite, hornblende, sphene, feldspar alterations, chlorite, epidote, iron ore, apatite, zircon.
730-740'
Cuttings
Jn-15-4
Some cores of plagioclase crystals are replaced by a semi-isotropic clay while others are replaced by a mat of small sericite shreds; notably less epidote is present; biotite, hornblende, and to a lesser extent sphene, have a sieve structure; chlorite is interlayered with biotite but also occurs as complete pseudomorphs associated with granular sphene; exceptionally large and abundant sphene crystals are noted; quartz grains are generally small and rounded in form and are gently strained. Grain size: to 3 mm but irregular. Texture: hypidiomorphic and crystalloblastic.

This well was located essentially on Eastern Arbuckle Province granite and penetrated approximately 750 feet of this granite before cutting a thrust fault and entering lower Paleozoic strata. The fault penetrated is one of the main faults within the Arbuckle Mountains. Here the Eastern Arbuckle Province granite is notable for its metamorphic effects and for the absence of cataclastic features even though it is in contact with a major Paleozoic fault.

KIOWA COUNTY

TIDEWATER-SKELLY OIL CO., 1 SMITH NW SW SE 23-7N-20W (Kw-3)

Anorthosite...... Plagioclase (89%), calcite (4%), zeolitic alterations (4%), chlorite (2%), iron ore (1%), fluorite (tr.), dustlike inclusions (tr.).
1683-1688'
Core
Kw-3-1
An anhedral mosaic of intermediate labradorite is associated with a small amount of chlorite, probably after pyroxene; zeolitic alterations replace plagioclase irregularly; calcite is in small veins and as an intergranular mineral; fine irregularly shaped opaque inclusions are present in the plagioclase. Grain size: to 3 mm. Texture: xenomorphic.

This is an excellent anorthosite of the Raggedy Mountain Gabbro Group and, unlike many representatives of this group in subsurface, it shows no cataclastic effects.

WARLICK, 1 WAYNE NE SE SE 2-7N-18W (Kw-8)

Micrographic granite...... Perthite (61%), quartz (31%), iron ore (3%), hornblende (2%), biotite (2%), clay minerals (1%), fluorite (tr.), apatite (tr.), zircon (tr.).
1612-1622'
Cuttings
Kw-8-1
Perthite is clouded with alterations and hematite dust; quartz is in delicate micrographic intergrowth and large strained crystals; accessory minerals are in clots with hornblende dominating fluorite, apatite, and zircon; feldspar may be a microcline perthite but clouding makes petrographic determination impossible. Grain size: to 4 mm. Texture: micrographic to hypidiomorphic.

A normal rock of the Wichita Granite Group.

WEGENER DRLG. CO., 1 BRETCH NW NW SW 5-7N-18W (Kw-10)

Microgranite...... Perthite (65%), quartz (32%), iron ore (2%), biotite (1%), sericite (tr.), chlorite (tr.), fluorite (tr.), apatite (tr.).
1780-1795'
Cuttings
Kw-10-1
Perthite partly subhedral with interstitial quartz; hematite veinlets cloud perthite; magnetite associated with minor biotite, chlorite and sericite; texture approaches aplite in some chips. Grain size: to 0.9 mm. Texture: hypidiomorphic.

This granite is finer grained than the average but is probably a phase of a normal rock of the Wichita Granite Group.

LEWIS & MEYER, 1 FOWLER SE SE NW 10-7N-18W (Kw-11)

Diabase...... Plagioclase (53%), pyroxene (23%), iron ore (9%), chlorite (6%), uralitic hornblende (4%), biotite (3%), calcite (2%), quartz (tr.), sericite-zeolite (tr.), apatite (tr.).
1578-1588'
Cuttings
Kw-11-1
Plagioclase appears to be calcic andesine and is clouded with opaque inclusions and sericite-zeolite alterations; many skeleton crystals of magnetite are present; biotite is deep blue green and is possibly primary in part; pyroxene is intergranular and clouded, and is altering to chlorite and uralitic hornblende. Grain size: to 1 mm. Texture: porphyritic and intergranular.

Diabase...... Plagioclase (47%), pyroxene (21%), iron ore (12%), biotite (4%), basaltic hornblende (12%), quartz (2%), calcite (2%), sericite (tr.), apatite (tr.).
1665-1675'
Cuttings
Kw-11-2
Plagioclase phenocrysts of calcic labradorite are set in a groundmass of slightly more sodic plagioclase laths; plagioclase contains lines of opaque globular inclusions; red-brown biotite and brown basaltic hornblende are associated with cloudy pyroxene crystals containing iron ore granules; quartz is irregular but appears to be primary; calcite replaces portions of the groundmass. Grain size: to 1 mm.

Lewis & Meyer, 1 Fowler (cont.)
Texture: porphyritic and intergranular.

The basement rock in this well is interpreted as a thick diabasic intrusive into the Wichita Granite Group. The relative uniformity and the thickness drilled (107 feet) suggests a high-angle dike or thick sill was penetrated.

LEWIS & MEYER, 1 FORD NE NE SE 14-7N-18W (Kw-13)

1420-1485'
Cuttings
Kw-13-1

Granite or quartz monzonite...... Microcline perthite (30%), quartz (29%), plagioclase (27%), biotite (6%), iron ore (3%), calcite (2%), clay-sericite (2%), chlorite (tr.), fluorite (tr.), hornblende (tr.), sphene (tr.), apatite (tr.), zircon (tr.). Patch-type microcline perthite and oligoclase are altering to minor clay-sericite; large olive-green biotite contains zircon and apatite inclusions, both with pleochroic halos; a small amount of fresh hornblende is associated with biotite, and both are altering to minor chlorite; calcite as small irregular blebs. Grain size: to 2.5 mm. Texture: hypidiomorphic.

The exceptionally high biotite content and abundant free plagioclase suggest that this is perhaps a contaminated rock of the Wichita Granite Group. Nearby wells penetrated typical Wichita granite.

WHITTING ET AL., 1 PATCHIN NE NW NW 28-7N-18W (Kw-15)

1420-1424'
Cuttings
Kw-15-1

Granite...... Perthite (66%), quartz (27%), iron ore (2%), biotite (2%), riebeckite (1%), hornblende (tr.), calcite (tr.), leucoxene (tr.), apatite (tr.), zircon (tr.). Perthite is clouded with minor alterations and hematite dust; riebeckite is associated with biotite and common hornblende; the coarseness of the granite makes textural relationships obscure. Grain size: to 5 mm. Texture: hypidiomorphic?

The relative coarseness and the presence of riebeckite are not common in rocks of the Wichita Granite Group, but similar granites are known in the Wichita Mountains.

H. F. WILCOX, 1 GRIESER SW SW NE 35-7N-18W (Kw-17)

1460'
Core
Kw-17-1

Olivine-pyroxene rock...... Iron ore (28%), olivine (27%), pyroxene (20%), calcite (8%), chlorite (9%), iddingsite (2%), apatite (2%), plagioclase (2%), basaltic hornblende (1%). Large rounded olivine crystals contain cracks replaced by magnetite and chlorite; iddingsite as partial and total pseudomorphs after olivine; pyroxene contains schiller iron ore; calcite is in veins and as an ultra fine-grained mass, perhaps associated with another mineral; magnetite is intergranular and contains large apatite crystals; plagioclase is intergranular and sparse; basaltic hornblende forms partial rims around iron ore. Grain size: to 3 mm. Texture: xenomorphic.

This rock is unique when compared to other rocks in the subsurface or to rocks from the outcrop. It is perhaps a segregation or an unusual dike but it is undoubtedly allied to the Raggedy Mountain Gabbro Group.

A. BAKER, 1 COPELEY NW NE SE 30-7N-17W (Kw-19)

1268-1289'
Cuttings

Granite and basalt...... Samples from this well were too poor for petrographic examination. The granite is an example of the Wichita Granite Group and the basalt found lower in the well is interpreted as a representative of the Navajoe Mountain Basalt-Spilite Group. This is substantiated by the Lewis, 1 Coakley (Kw-75) in the same section and Pearson, 1 Folks (Kw-66) a mile to the southeast.

STAUFFER PETR. CO., 1 MAYO NE NE NW 13-6N-18W (Kw-25)

1068-1082'
Cuttings
Kw-25-1

Altered gabbro...... Labradorite, calcite, iron ore, chlorite, zeolite alterations, sericite, apatite, acicular inclusions. Intergranular calcite and chlorite are pseudomorphic after pyroxene; small amounts of sericite and zeolite are after plagioclase; plagioclase contains numerous opaque acicular inclusions. Photomicrograph, pl. 3. Grain size: to 6 mm. Texture: hypidiomorphic.

1090-1118'
Cuttings
Kw-25-2

Contaminated microgranite...... Perthite (60%), quartz (11%), chlorite (10%), iron ore (8%), biotite (6%), calcite (3%), plagioclase (2%), apatite (tr.), feldspar alterations (tr.). Perthite is much clouded with feldspar alterations and hematite dust; biotite contains abundant chlorite and calcite alterations; magnetite replaces portions of the mafic minerals; minor microbrecciation is present; the low quartz and exceptionally high mafic mineral contents suggest that this granite intrusion into the older gabbroic rocks has been contaminated by assimilating the more basic rocks. Grain size: to 0.7 mm. Texture: hypidiomorphic.

1161-1181'
Cuttings
Kw-25-3

Altered gabbro...... Plagioclase, iron ore, pyroxene, calcite, sericite-zeolite, biotite, apatite, rutile(?). Intermediate labradorite is highly altered and contains minor brecciation; calcite replaces extensively; pyroxene contains schiller iron ore with some symplectic magnetite-pyroxene intergrowth; biotite and common chlorite as a replacement of pyroxene in some chips. Grain size: 4 mm+. Texture: hypidiomorphic.

1189-1220'
Cuttings
Kw-25-4

Anorthosite...... Labradorite, zeolite, calcite, iron ore, chlorite, biotite, sericite, rutile(?). The rock is almost wholly composed of intermediate labradorite and minor amounts of the other minerals; no original mafic mineral remains; several chips are cataclastically altered and contain badly crushed and smeared plagioclase. Grain size: 5 mm+. Texture: cataclastic and hypidiomorphic.

1272-1282'
Cuttings
Kw-25-5

Gabbro...... Labradorite, pyroxene, iron ore, calcite, zeolite, chlorite, sericite, biotite, apatite, rutile(?). The normal gabbro has been cataclastically altered with attendant development of zeolites and sericite; biotite replaces small amounts of the pyroxene and is found in breccia zones; clinopyroxene forms rims around orthopyroxene; minor magnetite-pyroxene is found in symplectic intergrowth; rutile(?) as inclusion needles in plagioclase. Grain size: 6 mm+. Texture: cataclastic and hypidiomorphic?

1510-1526'
Cuttings
Kw-25-6

Gabbro...... Labradorite, zeolite, pyroxene, calcite, chlorite, iron ore, clay, biotite, epidote, rutile(?). A highly brecciated and lineated gabbroic rock containing abundant alterations; cataclastic zones contain clay and zeolite; pyroxene contains some schiller iron ore; thin veins of calcite are common; rutile(?) as inclusion needles in plagioclase. Grain size: irregular. Texture: cataclastic.

1677-1704'
Cuttings
Kw-25-7

Anorthosite...... Labradorite, clay-zeolite, calcite, chlorite, iron ore, biotite, sericite, rutile(?). Some highly mylonized zones have developed abundant clay-zeolites, chlorite, biotite and calcite; plagioclase contains minor sericite; alteration varies from cataclastic effects to mylonization. Grain size: irregular. Texture: cataclastic.

This sequence of the Raggedy Mountain Gabbro Group shows almost universal alteration and cataclastic effects. The granitic interval from 1,090 to 1,118 feet is interpreted as a dike or sill of Wichita granite penetrating into the older gabbroic rocks.

HARBER & POLK, 1 PARR SW SW SW 32-6N-17W (Kw-27)

A core of anorthosite at 1,362 feet shows that the basement rock of this well is in the Raggedy Mountain Gabbro Group.

MALERNEE OIL CO., 1 CLEVELAND SW SW SE 11-6N-15W (Kw-33)

Rhyolite porphyry...... Phenocrysts: perthite (12%), quartz (6%), plagioclase (3%), iron ore (2%); groundmass (77%): chlorite, sphene-leucoxene, feldspar alterations, apatite, zircon. Phenocrysts of feldspar contain minor sericite alterations; iron ore granules associated with apatite and zircon and contain alterations to sphene-leucoxene; quartz phenocrysts are rounded and embayed and have a rim of optically continuous groundmass quartz; clots of fibrous chlorite are possibly pseudomorphous after a former mafic mineral. Grain size: phenocrysts to 2 mm. Texture: porphyritic and spherulitic.

410-475'
Cuttings
Kw-33-1

This example of the Carlton Rhyolite Group was penetrated along the Blue Creek Canyon anticline and is similar to rhyolite cropping out in the immediate area.

HURST & GROTH, 1A GROTH SW SW SW 3-4N-16W (Kw-46)

Gabbro...... Plagioclase, pyroxene, iron ore, chlorite, calcite, tremolitic amphibole, biotite, acicular inclusions. Large euhedral to subhedral pyroxene crystals are altering to chlorite and tremolite or a symplectic intergrowth of calcite and magnetite with a colorless amphibole; minor untwinned sodic plagioclase associated with biotite is present in one chip; plagioclase contains tiny hairlike needles. Grain size: greater than 6 mm. Texture: questionable.

226-235'
Cuttings
Kw-46-1

Olivine gabbro...... Plagioclase, pyroxene, olivine, iron ore, calcite, chlorite, iddingsite, apatite, acicular inclusions, zircon. Undetermined plagioclase contains tiny acicular inclusions; a symplectic intergrowth of plagioclase and a mafic mineral, altering to biotite, is present; large apatite crystals included in the pyroxene; one zircon crystal noted, rare in this type of rock; iddingsite is formed along cracks in olivine in association with iron ore. Grain size: greater than 6 mm. Texture: questionable.

380-395'
Cuttings
Kw-46-2

This well, drilled a few miles south of the Raggedy Mountains, penetrated typical gabbro of the Raggedy Mountain Gabbro Group.

YOUNG OIL CO., 1 COOK NE NE NW 33-2N-16W (Kw-49)

Basic hornfels...... Intermediate plagioclase (34%), pyroxene (23%), iron ore (17%), biotite (9%), quartz (8%), tremolitic amphibole (5%), apatite (2%), sphene (tr.). Areas of biotite-rich rock alternate with areas lacking biotite; magnetite granules are extremely numerous and variable in size; pyroxene is granular and locally clouded with tremolitic amphibole; plagioclase is untwinned and completely unaltered. Grain size: 0.1 mm average. Texture: granoblastic.

670-677'
Cuttings
Kw-49-1

This rock is interpreted as a basic lava of the Navajoe Mountain Basalt-Spilite Group converted by the Wichita granites to a hornfels. The well is located a few miles south of granite outcrop and four miles north of a less metamorphosed basalt found in the Buel and Herdon, 1 Haught (Tl-15) in 22-1N-16W.

BARTON & POLK DRLG. CO., 1 PARR SW SW SW 22-6N-17W (Kw-54)

Anorthosite...... Plagioclase (81%), iron ore (12%), pyroxene (2%), zeolite (2%), basaltic hornblende (1%), biotite (1%), chlorite (tr.), acicular inclusions (tr.). Minor breccia zones contain zeolites; magnetite is in a local intergranular area; basaltic hornblende and biotite as a partial rim around iron ore; pyroxene is in discrete intergranular crystals. Grain size: to 10 mm. Texture: hypidiomorphic.

1265-1269'
Core
Kw-54-1

The thin section from the core contains an abnormal amount of magnetite which appears in small local clots. The rock is an example of the Raggedy Mountain Gabbro Group.

PEARSON, 1 FOLKS SE SW NW 32-7N-17W (Kw-66)

Analcime basalt...... Plagioclase (46%), pyroxene (19%), chlorite (11%), iron ore (9%), biotite (8%), amphibole (4%), quartz (3%), clay-zeolite (tr.), apatite (tr.). Plagioclase is andesine (An_{40}) and contains minor sericite-zeolite alterations but is generally fresh; yellowish-red biotite is probably primary; feathery needles and comb-shaped crystals of magnetite are present; chlorite replaces both the pyroxene and biotite. One large chip, not thin sectioned, contains an analcime trapezohedron on the wall of a vesicule. Grain size: 0.5 mm. Texture: intergranular.

1428-1435'
Cuttings
Kw-66-1

This well is at the north edge of the central Wichita block. It penetrated a lava of the Navajoe Mountain Basalt-Spilite Group, in the only area north of the Wichita Mountains where rocks of this group are penetrated at shallow depth. See also the Lewis, 1 Coakley (Kw-75).

WALTERS (DeBOLT), 1 McCURDY NW SE SE 7-6N-17W (Kw-70)

Gabbro...... Plagioclase, pyroxene, iddingsite, iron ore, chlorite, zeolite, calcite, apatite, acicular inclusions. Plagioclase contains fine hairlike inclusions; orthopyroxene is clear and contains schiller iron ore; pale-brown clinopyroxene forms a rim around orthopyroxene; iddingsite is distinct and pseudomorphic after olivine; apatite crystals exceptionally large. Grain size: 4 mm+. Texture: hypidiomorphic.

945-957'
Cuttings
Kw-70-1

This gabbro is a part of the Raggedy Mountain Gabbro Group. The occurrence of iddingsite indicates it was originally an olivine gabbro.

ANDERSON-PRICHARD OIL CORP., 1 CRIBBS SE SE NE 28-7N-19W (Kw-74)

Granite...... Samples of this granite are unsuitable for thin-section analysis. It is interpreted as a representative of the Wichita Granite Group.

1685-1825'
Cuttings

A. L. LEWIS, 1 COAKLEY SE NE SE 30-7N-17W (Kw-75)

Granite...... Microcline perthite (52%), quartz (28%), plagioclase (13%), iron ore (3%), chlorite (2%), calcite (1%), sericite (tr.), zircon (tr.), sphene-leucoxene (tr.). Delicate string- and patch-type perthite contains well-defined microcline twinning; plagioclase is more clouded than the perthite and contains sericite alterations and hematite dust; quartz is large and unstrained; chlorite replaces a former mafic mineral and contains a small amount of sphene-leucoxene in association. Grain size: to 3 mm. Texture: hypidiomorphic.

1250-1270'
Cuttings
Kw-75-1

A. I. Lewis, 1 Coakley (cont.)

Altered andesite...... Plagioclase alterations, plagioclase, iron ore, biotite, chlorite, calcite, apatite. A highly altered andesite containing only relicts of formerly abundant plagioclase; biotite and chlorite replaces a former mafic mineral that is probably hornblende; plagioclase crystals are trachytically aligned in one chip; calcite replaces irregularly but has almost completely replaced one chip. Grain size: to 1.5 mm. Texture: relict trachytic.

1250-1278'
Cuttings
Kw-75-2

This well contains rock of the Wichita Granite Group cutting and altering the older andesite of the Navajoe Mountain Basalt-Spilite Group. This interpretation is substantiated by similar rock in the Baker, 1 Copely (Kw-19) in the same section and basalt found in the Pearson, 1 Folks (Kw-66) a mile to the south.

RUSSEL & SLOAN, 1 PETTY 14-6N-15W (Kw-76)

Diabase...... This well contained a fine-grained basic rock, probably diabase. The diabase probably cuts Carlton rhyolite, for rhyolite is known in wells in the immediate area and in nearby outcrops.

495-500'
Cuttings

VAN KIRK, 1 MALERNEE NW NW NW 35-7N-15W (Kw-79)

Rhyolite porphyry...... Phenocrysts: plagioclase (12%), iron ore (4%); groundmass (84%): potash feldspar, quartz, chlorite, leucoxene, apatite, feldspar alterations, zircon, calcite. Phenocrysts of sodic plagioclase are set in a groundmass of delicate but well-defined quartz-feldspar spherulites; interspherulite material is dominantly quartz; sparse amygdules are filled with quartz and chlorite. Grain size: phenocrysts to 1.5 mm. Texture: porphyritic and spherulitic.

516-530'
Cuttings
Kw-79-1

Rhyolite porphyry...... Phenocrysts: perthite (9%), plagioclase (3%), iron ore (2%); groundmass (84%): pyrite (1%), quartz, chlorite, calcite, leucoxene, biotite, apatite, zircon. Large phenocrysts of perthite are rounded and somewhat embayed; plagioclase phenocrysts are smaller and more nearly euhedral; quartz present in spherulites with feldspar but is best developed as an interspherulite material; one chip has a silicifed groundmass; pyrite as distinct cubes; spherulites are primary having pale-brown cores and deep-red outer margins. Grain size: phenocrysts to 2 mm. Texture: porphyritic and spherulitic.

684-695'
Cuttings
Kw-79-2

Rhyolite porphyry...... Phenocrysts: plagioclase (9%), perthite (8%), quartz (4%), iron ore (2%); groundmass (77%): chlorite, calcite, sphene-leucoxene, apatite, zircon. Large rounded perthite phenocrysts have up to six optic units indicating a modified glomeroporphyry; all phenocrysts have iron-stained rims; some plagioclase phenocrysts have perthite rims; quartz phenocrysts are highly embayed; groundmass contains spicular quartz needles. Grain size: phenocrysts to 2 mm. Texture: porphyritic and spherulitic.

735-745'
Cuttings
Kw-79-3

Perlitic rhyolite porphyry...... Phenocrysts: perthite (11%), plagioclase (6%), iron ore (3%), quartz (2%); groundmass (78%): chlorite, calcite, zircon. Perlitic cracks are outlined by iron ore and contain rather coarse cores of feldspar and quartz with associated chlorite; minor quartz veins present; plagioclase phenocrysts are delicately twinned; perthite phenocrysts are rounded and wormy in appearance; quartz phenocrysts are rounded and highly embayed. Grain size: phenocrysts to 1.8 mm. Texture: porphyritic and perlitic.

835-845'
Cuttings
Kw-79-4

Van Kirk, 1 Malernee (cont.)

This well penetrated rocks of the Carlton Rhyolite Group along the axis of the Blue Creek Canyon anticline. They are similar to rocks cropping out a few miles to the southeast.

RADAR OIL CO., 29-1 GERBER NE NE SE 29-6N-17W (Kw-81)

Anorthosite...... Plagioclase, zeolite-clay, calcite, iron ore, sericite, biotite, pyroxene, rutile (?). One cutting chip is cataclastically altered and contains chlorite and relicts of pyroxene; crushed zones contain chlorite and clay-zeolite; plagioclase contains fine hairlike needles of rutile(?) as inclusions; well-crystallized calcite dominates one chip and is common in veins. Grain size: 6 mm and greater. Texture: cataclastic and hypidiomorphic.

1390-1397'
Cuttings
Kw-81-1

The cataclastic features of this anorthosite are common in the Raggedy Mountain Gabbro Group.

MORROW, 1 BOZMAN SE SE NE 14-5N-18W (Kw-82)

Anorthosite...... Plagioclase, chlorite, iron ore, zeolite, biotite, sericite, epidote, pyroxene, apatite, acicular inclusions. Most chips are composed of labradorite containing hairlike inclusions; minor chlorite is associated with relicts of pyroxene; small biotite flakes are associated with iron ore in one chip; plagioclase is generally fresh. Grain size: to 5 mm. Texture: hypidiomorphic.

460-465'
Cuttings
Kw-82-1

This well is located on the relatively undisturbed axial part of the central Wichita block. The rock is a representative of the Raggedy Mountain Gabbro Group.

KLEIN, 1 VAN KIRK NE NE SW 35-7N-15W (Kw-84)

Rhyolite porphyry...... Phenocrysts: perthite (10%), quartz (8%), iron ore (5%); groundmass spherulites (52%), fine groundmass (24%), feldspar alterations, leucoxene, zircon. Large perthite phenocrysts are rounded and embayed; quartz phenocrysts are smaller and also highly embayed; exceptionally well-developed spherulites are radial around the phenocrysts; interspherulite material is a fine felsophyric quartz-feldspar intergrowth; iron ore crystals have ragged borders and zircon in association. Grain size: phenocrysts to 5 mm. Texture: porphyritic and spherulitic.

520-530'
Cuttings
Kw-84-1

Diabase...... Plagioclase (52%), pyroxene (22%), iron ore (8%), iddingsite (7%) chlorite (4%), calcite (3%), sphene (1%), fluorite (tr.), apatite (tr.). Coarse pyroxene crystals ophitically enclose labradorite laths; iddingsite is after olivine and is poorly distributed; sphene and hematite are associated with magnetite crystals; fibrous chlorite replaces pyroxene. Grain size: to 2 mm. Texture: ophitic.

520-530'
Cuttings
Kw-84-2

This well penetrated a little rhyolite of the Carlton Rhyolite Group and more than 70 feet of diabase, probably cutting the rhyolite. The well is located along the Blue Creek Canyon anticline.

HUGHES, 1 FOLTZ SE SE SE 10-6N-18W (Kw-88)

Gabbro...... Plagioclase, zeolite-clay, biotite, iron ore, chlorite, calcite, pyroxene, acicular inclusions. A highly altered and cataclastically smeared gabbro; calcic labradorite contains oriented hairlike inclusions; zeolite-clay, biotite, and chlorite are developed along mylonitic lineations; a possibly primary red-brown variety of biotite occurs with a secondary green fibrous variety; pyroxene occurs as small relicts. Grain size: to 6 mm. Texture: cataclastic.

1189-1199'
Cuttings
Kw-88-1

The cataclastic effects relfect the relative closeness of this well to a major northwest-trending fault. The rock is an example of the Raggedy Mountain Gabbro Group.

BEELER, 1 PATTON NE NE NE 11-6N-15W (Kw-89)

Rhyolite porphyry...... Phenocrysts: perthite (9%), quartz (4%), plagioclase (3%); groundmass (82%): iron ore (2%), biotite, chlorite, leucoxene, feldspar alterations, zircon. Feldspar phenocrysts contain inclusions of chlorite, biotite, and iron ore; delicate spherulites are present, some with cores of highly embayed quartz; titaniferous magnetite altering to leucoxene; amygdules are filled with chalcedonic quartz; green and reddish biotite is secondary and associated with iron ore. Grain size: phenocrysts to 1.3 mm. Texture: porphyritic and spherulitic.

436-446'
Cuttings
Kw-89-1

Rhyolite porphyry...... Phenocrysts: perthite (6%), plagioclase (3%), iron ore (2%); groundmass (89%): quartz, chlorite, calcite, feldspar alterations, sphene, leucoxene, zircon. The groundmass is a devitrified glass containing relict flow lines represented by iron ore trails distorted around phenocrysts; amygdules are filled with quartz and chlorite; groundmass is highly spherulitic; perthite phenocrysts are wormy and embayed whereas plagioclase phenocrysts are euhedral to subhedral. Grain size: phenocrysts to 1.2 mm. Texture: porphyritic and spherulitic.

511-517'
Cuttings
Kw-89-2

This well penetrated rock of the Carlton Rhyolite Group along the axis of the Blue Creek Canyon anticline.

DARBY-EVEREST CO., 1 FULLINGIN NW NW SE 24-3N-16W (Kw-95)

Gabbro...... Plagioclase, pyroxene, iron ore, iddingsite, zeolite, chlorite, biotite, rutile(?). Labradorite contains oriented rutile(?) needles as inclusions; minor zeolite veins are present in the plagioclase; cores of brownish orthopyroxene containing schiller iron ore have a rim of clear clinopyroxene; iddingsite as large masses after olivine; biotite as sparse shreds associated with iron ore; chlorite as a minor vein mineral. Grain size: to 3 mm. Texture: hypidiomorphic.

165-170'
Cuttings
Kw-95-1

This well penetrated rock of the Raggedy Mountain Gabbro Group and is located less than two miles south of gabbro outcrop.

REX WHISTLER, 1 AHDOKOBO NE NE NE 25-5N-15W (Kw-98)

Diabase...... Pyroxene, labradorite, basaltic hornblende, clay, chlorite, biotite, apatite, calcite. A poor thin section of a highly altered rock; plagioclase is present in residual patches and is highly altered to clay; brown basaltic hornblende is common; pyroxene is clouded and altering to chlorite; apatite is abnormally abundant. Grain size: to 3 mm. Texture: questionable.

203-204'
Core
Kw-98-1

This diabase probably intruded rocks of the Wichita Granite Group that crop out less than a mile to the south.

J. P. DAY, 1 McELROY SW NW SW 30-2N-16W (Kw-99)

Gabbro...... Plagioclase (54%), pyroxene (29%), iron ore (12%), tremolitic amphibole (2%), biotite (2%), chlorite (1%), feldspar alterations (tr.), apatite (tr.), acicular inclusions (tr.). Subhedral labradorite laths are associated with granular pyroxene; pyroxene contains iron ore granules and is in groups of crystals; red-brown biotite is large but sparse and poorly distributed; tremolitic amphibole replaces pyroxene; some large plagioclase crystals in a symplectic intergrowth with pyroxene. Photomicrograph, pl. XIII-4. Grain size: to 2 mm. Texture: hypidiomorphic.

500-550'
Cuttings
Kw-99-1

This rock is a representative of the Raggedy Mountain Gabbro Group, though it is finer grained than the normal type. The rock is unusually fresh. The well is located only a few miles south of the granite hills near the town of Snyder.

REINHART & DONOVAN, 1 HEFNER SW SW SW 32-5N-16W (Kw-101)

Cuttings from a depth of 247 feet are too small to pick for a thin section, but the rock appears to be anorthosite containing only a trace of mafic minerals. It is assigned to the Raggedy Mountain Gabbro Group.

IRRIGATION PRODUCTS INC., 1 BOYDSTON SW SE SW 31-5N-17W (Kw-117)

Quartz monzonite...... Plagioclase (37%), potash feldspar (23%), quartz (21%), hornblende (13%), biotite (5%), iron ore (tr.), chlorite (tr.), rock paste (tr.), sphene (tr.), feldspar alterations (tr.), pyroxene (tr.), apatite (tr.), zircon (tr.). This slide was etched and stained to differentiate potash from soda feldspar; the exceptionally high mafic-mineral content and abundance of free plagioclase strongly suggest that this rock is the product of a granite magma assimilating basic material, such as is found on the outcrop in the Cold Springs area; the plagioclase is oligoclase and the larger euhedral crystals have sericitized cores; several slippage planes contain pulverized rock paste; micrographic intergrowth is irregular and delicate; erratic staining of feldspars suggests that perthite is present but petrographic evidence is lacking; hornblende is deep green and biotite is brownish and strongly pleochroic. Grain size: to 1.4 mm. Texture: hypidiomorphic and micrographic.

269-281'
Core
Kw-117-1

This well was drilled in an area close to outcrops of gabbro and the presence of the granitic rock was not anticipated. Irregular areas of contaminated granite are present on the outcrop approximately 4 miles to the south and this well is interpreted as penetrating the subsurface extension of the contaminated granite.

SHELL OIL CO., 1 LONE WOLF UNIT C NE NE 4-5N-15W (Kw-119)

Rhyolite porphyry...... Phenocrysts: quartz, perthite; groundmass: feldspar alterations, chlorite, leucoxene, iron ore, apatite, zircon. Well-defined perlitic cracks are preserved in a strongly banded and highly sericitized groundmass; some chips have a groundmass suggestive of a tuffaceous origin in the distribution and shape of the amygdule fillings; large quartz phenocrysts are shattered and the cracks filled with groundmass material; the feldspar phenocrysts are extensively altered and replaced, with only relicts of perthite remaining; chlorite replacement of feldspar is associated with sericite, both in tiny unoriented shreds; banding in the groundmass is caused by inhomogeneous mineralogy, which is reflected in the textural variation in the bands; in general the iron-stained feldspar-rich bands are spherulitic and the lighter quartz-rich bands are perlitic. Grain size: phenocryst relicts greater than 2.5 mm. Texture: porphyritic, spherulitic, and perlitic.

4355-4398'
Cuttings
Kw-119-1

This is the only well for which samples were obtained in the Rainy Mountain syncline. It penetrated extrusive rocks of the Carlton Rhyolite Group.

MURRAY COUNTY

FRANKFORT, 1 SPARKS RANCH C SE SE 32-1S-1W (Mr-1)

6860-6870' Cuttings Mr-1-1

Lithic tuff...... Phenocrysts: quartz (2%), iron ore (1%); groundmass (96%): pyrite (1%), feldspar alterations, zircon. Rock appears to be composed of fragments of rhyolite groundmass with a few detrital quartz fragments; the paucity of phenocrysts is unusual; matrix is high in quartz content; iron ore and silica introduction obscures original character of the rock. Grain size: fragments to 2 mm. Texture: poorly sorted, pyroclastic.

7040-7050' Cuttings Mr-1-2

Devitrified perlite...... Iron ore phenocrysts (2%), groundmass (98%), feldspar, quartz, chlorite, sericite, calcite, pyrite. Some larger development of feldspars occurs in cores of devitrified perlites; perlite cracks appear to control devitrification and secondary mineralization; aligned opaque inclusions indicate former flow fabric destroyed by devitrification; chlorite replaces along perlitic cracks; sericite is a common replacement of feldspars. Grain size: phenocrysts to 0.5 mm. Texture: perlitic and porphyritic.

7080-7090' Cuttings Mr-1-3

Lithic tuff...... Matrix (52%), lithic fragments (22%), feldspar fragments (11%), quartz (4%), chlorite (4%), pyrite (3%), calcite (2%), iron ore (2%), sericite (tr.), zircon (tr.). Lithic and mineral fragments are in a chertose matrix of quartz and feldspar; sorting appears poor, as fragments range from size of silt up to lithic detritus 2 mm in diameter; lithic fragments are diverse types of rhyolite groundmass; chlorite in some detrital fragments appears to be predepositional, indicating chlorite deuterically introduced rather than a weathering mineral; feldspar mostly perthite groundmass fragments. Grain size: to 2 mm. Texture: poorly sorted, pyroclastic.

7190-7200' Cuttings Mr-1-4

Lithic tuff...... Matrix (47%), lithic fragments (32%), feldspar (13%), quartz (3%), chlorite (2%), pyrite (2%), magnetite (1%), calcite (tr.), sphene (tr.), epidote (tr.). Lithic fragments mostly diverse types of rhyolite groundmass, one appears trachytic; several basic lithic fragments appear highly altered and are possibly a low-grade metamorphic rock; matrix is dustlike mineral and lithic fragments; feldspar is mostly perthite with some minor plagioclase. Grain size: to 2.5 mm. Texture: poorly sorted, pyroclastic.

7500-7510' Cuttings Mr-1-5

Rhyolite agglomerate...... Groundmass, feldspar, quartz, lithic fragments, chlorite, iron ore, pyrite, sphene, apatite, zircon. Three chips are composed of texturally different rhyolite porphyries; others are crystal to lithic tuffs containing many quartz and feldspar fragments and some rhyolite groundmass detritus; apatite and chlorite are well developed in one tuffaceous chip; chips of rhyolite are probably agglomeratic blocks in the crystal-lithic tuff matrix. Grain size: diverse. Texture: coarse textured, pyroclastic.

7820-7840' Cuttings Mr-1-7

Diabase...... Plagioclase (53%), pyroxene (22%), iron ore (11%), chlorite (7%), iddingsite(?) (4%), biotite (1%), amphibole (1%), calcite (tr.), sphene (tr.), apatite (tr.), feldspar alterations (tr.). Sodic labradorite cut by delicate veinlets containing alteration products and calcite; some untwinned plagioclase resembling quartz; sparse uralitic hornblende after pyroxene; iddingsite in a fibrous mat indicating original olivine. Grain size: to 1.2 mm. Texture: subophitic.

Frankfort, 1 Sparks Ranch (cont.)

8020-8030' Cuttings Mr-1-6

Rhyolite porphyry...... Phenocrysts: feldspar (13%), quartz (7%), iron ore (3%); groundmass (77%): sphene, epidote, apatite. A thick thin section that appears to be rhyolite with one chip of tuffaceous origin; one feldspar phenocryst is exceptionally large and contains poikilitically enclosed chlorite; iron ore as magnetite granules and smaller crystals in groundmass; hematite dust colors groundmass. Grain size: phenocrysts to 2.5 mm. Texture: spherulitic and porphyritic.

8410-8420' Cuttings Mr-1-8

Perlitic rhyolite porphyry...... Phenocrysts: feldspar (12%), iron ore (4%); groundmass (84%): quartz, chlorite, calcite, sphene-leucoxene, sericite, apatite, zircon. Large, well-formed, primary spherulites with pale-brown core and more reddish rim are set in a perlitic to spherulitic groundmass; perlitic cracks defined by later chlorite; perlites devitrify to a finely spherulitic texture; phenocrysts of feldspar contain apatite inclusions and later calcite, sericite, and chlorite; iron ore as irregular granules with sphene-leucoxene alterations. Photomicrograph, pl. VIII-2. Grain size: phenocrysts to 1.8 mm. Texture: porphyritic, perlitic, and spherulitic.

8470-8490' Cuttings Mr-1-9

Perlitic rhyolite porphyry...... Phenocrysts: plagioclase (11%), iron ore (4%), potassium feldspar (3%); groundmass (82%): quartz, chlorite, sericite, sphene-leucoxene, apatite, zircon. Perlites well defined but completely devitrified to an inequigranular groundmass; iron ore as large smooth granules and ragged dust in groundmass; sericite replaces feldspar in groundmass, usually near the cores of perlites; possible minor potassium feldspar as wormy embayed phenocrysts; plagioclase also as embayed phenocrysts. Grain size: phenocrysts to 1.5 mm. Texture: porphyritic, perlitic, and spherulitic.

8550-8560' Cuttings Mr-1-10

Perlitic rhyolite porphyry...... Phenocrysts: perthite (13%), iron ore (3%); groundmass (84%): quartz, plagioclase, chlorite, sericite, apatite, zircon. Phenocrysts are highly embayed and ill defined with regard to the groundmass; perlite cores are single-mineral optic units and perlites seem to have controlled devitrification; some well-defined spherulites with feathery iron ore needles parallel to radial needles of spherulites; sericite replaces masses of feldspar irregularly. Grain size: phenocrysts to 1 mm. Texture: porphyritic, perlitic, and spherulitic.

8690-8700' Cuttings Mr-1-11

Lithic tuff...... Groundmass matrix (59%), lithic fragments (17%), quartz (9%), plagioclase (6%), potassium feldspar (6%), iron ore (3%), chlorite, calcite, sericite, leucoxene. Diverse rhyolite fragments include those of perlitic, spherulitic, felted, and porphyritic texture; detrital quartz is minor; sericite-chlorite masses common; one chip of devitrified perlite may be a large lithic fragment or represent a flow bed in this rock unit. Grain size: to 2 mm. Texture: poorly sorted, pyroclastic.

8790-8800' Cuttings Mr-1-12

Rhyolite porphyry...... Phenocrysts: plagioclase (7%), quartz (4%), perthite (3%), iron ore (2%); groundmass (84%): calcite, sericite, sphene-leucoxene, apatite, zircon. Highly spherulitic groundmass becomes micrographic at the coarser rims of spherulites; large areas of reconstituted quartz are optically continuous; feldspars clouded with hematite dust and alterations; perthite phenocrysts are wormy and embayed, plagioclase phenocrysts to a lesser extent; granules of sphene-leucoxene and feathery iron ore common in groundmass. Grain size: phenocrysts to 1 mm. Texture: porphyritic, spherulitic, and micrographic.

Frankfort, 1 Sparks Ranch (cont.)

Rhyolite porphyry...... Phenocrysts: plagioclase (12%), potassium feldspar (2%), iron ore (2%); groundmass (83%): quartz (1%), chlorite, calcite, sericite, apatite, zircon. Groundmass contains discrete spherulites set in a felted quartz-feldspar matrix; much calcite and chlorite replacement in groundmass; albite phenocrysts contain alterations and hematite dust; local linear coarsenings present in groundmass; apatite and zircon associated with iron ore granules. Grain size: to 1 mm. Texture: porphyritic, spherulitic, and felsophyric.
8960-8970'
Cuttings
Mr-1-13

Lithic tuff...... Groundmass matrix (59%), lithic fragments (17%), feldspar (8%), chlorite (6%), quartz (5%), sphene (2%), calcite (2%), sericite (1%), iron ore (tr.), apatite (tr.). Various types of rhyolite fragments with phenocryst portion clinging to some lithic detritus; matrix is extremely fine chertose quartz that locally merges with detrital fragments; abundant chlorite developed in some lithic fragments; sphene appears to have replaced most titaniferous iron ore. Grain size: to 0.9 mm. Texture: medium grained, pyroclastic.
9030-9040'
Cuttings
Mr-1-14

Rhyolite porphyry...... Phenocrysts: plagioclase (12%), quartz (4%), iron ore (3%); groundmass (81%): potassium feldspar, chlorite, calcite, sphene-leucoxene, apatite, feldspar alterations. Oligoclase phenocrysts contain enclosed chlorite-calcite-sphene in small but numerous groups; delicate spherulites become coarse and micrographic at outer margins; groundmass feldspar contains abundant hematite dust; quartz present in spherulitic intergrowth and as coarser interspherulitic material. Grain size: phenocrysts to 1.2 mm. Texture: porphyritic, spherulitic, and micrographic.
9540-9550'
Cuttings
Mr-1-15

Rhyolite porphyry...... Plagioclase phenocrysts (17%); groundmass (83%): feldspar, quartz, iron ore, chlorite, epidote, sphene, feldspar alterations. Suggestion of brecciation with silicification along breccia zones in one chip; primary pale-brown spherulites occur in a darker red groundmass; relict perlites occur in only one chip; epidote-sphene secondary, associated with chlorite; phenocrysts, which are calcic oligoclase, vary greatly in size. Grain size: to 2.5 mm. Texture: porphyritic, spherulitic, and relict perlitic.
9850-9860'
Cuttings
Mr-1-17

Diabase...... Plagioclase (45%), pyroxene (30%), iron ore (8%), chlorite (7%), zeolite-sericite (4%), micropegmatite (4%), sphene-leucoxene (2%), apatite (tr.). Labradorite altering to zeolite-sericite; delicate micrographic quartz and potassium feldspar intergrowth radial around some plagioclase; iron ore as skeletal crystals and granules altering to sphene-leucoxene; fibrous olive-green chlorite altering from pyroxene. Grain size: to 1 mm. Texture: subophitic.
9930-9940'
Cuttings
Mr-1-18

Rhyolite porphyry...... Phenocrysts: plagioclase (6%), perthite (3%), iron ore (2%); groundmass (89%): quartz, chlorite, calcite, biotite, sphene, epidote, apatite. Groundmass is xenomorphic granular and appears to be reconstituted and enriched in silica; small feldspar phenocrysts have irregular outlines; clear groundmass contains small masses of biotite and chlorite and small ragged granular masses of sphene. Grain size: to 1 mm. Texture: porphyritic and xenomorphic.
10540-10550'
Cuttings
Mr-1-19

Iron rich tuff(?)...... Iron ore, feldspar, quartz, chlorite, sphene-leucoxene, epidote, calcite, zeolite, apatite. Finely disseminated magnetite and sphene-leucoxene masses obscure much of slide; in cuttings the rock resembles a fine-grained diabase; the rock appears to be fine-grained tuffaceous material; most minerals are too fine grained for optical determination. Grain size: to 0.1 mm. Texture: relict clastic.
10910-10920'
Cuttings
Mr-1-20

Frankfort, 1 Sparks Ranch (cont.)

Rhyolite porphyry...... Phenocrysts: feldspar (21%), quartz (4%), iron ore (5%); groundmass (65%): epidote (3%), calcite (1%), chlorite, sphene, fluorite. Perthite phenocrysts are exceptionally numerous and variable in size; well-developed spherulites subradial around some phenocrysts; later phenocrysts are marginally frayed, whereas smaller perthites are euhedral and not embayed; interspherulite material high in quartz; epidote is developed along linear trends with minor fluorite and as discrete crystals and crystal groups in groundmass. Grain size: to 1 mm. Texture: porphyritic, spherulitic, and xenomorphic.
11250-11260'
Cuttings
Mr-1-21

Micrographic granite porphyry...... Perthite (50%), quartz (32%), plagioclase (11%), iron ore (4%), chlorite (2%), sphene-leucoxene (1%), calcite (tr.), epidote (tr.), apatite (tr.), zircon (tr.), fluorite (tr.). Radial to subradial micrographic quartz-perthite intergrowth is around oligoclase phenocrysts; some small nonintergrown quartz crystals; magnetite granules are associated with apatite and zircon; epidote is intergranular; calcite-chlorite-sphene appear to be replacing a former amphibole; feldspars dusty and clouded. Grain size: to 1.5 mm. Texture: micrographic and porphyritic.
11390-11400'
Cuttings
Mr-1-22

Micrographic granite porphyry...... Perthite (44%), quartz (34%), plagioclase (15%), iron ore (2%), augite (2%), biotite (2%), amphibole (tr.), epidote (tr.), sphene-leucoxene (tr.), apatite (tr.), zircon (tr.). Oligoclase phenocrysts have rims of radial to subradial micrographic intergrowth; augite well crystallized, showing alteration to pale-green amphibole and yellow-brown biotite; biotite also occurs as disseminated shreds in trends; feldspars contain hematite dust and minor alterations. Grain size: to 2.7 mm. Texture: micrographic and porphyritic.
11840-11850'
Cuttings
Mr-1-23

Micrographic granite porphyry...... Perthite (49%), quartz (33%), plagioclase (12%), iron ore (3%), amphibole (1%), biotite (1%), chlorite (tr.), augite (tr.), epidote (tr.), sphene (tr.), apatite (tr.), zircon (tr.). Similar to previous samples; amphibole appears primary as well as uralitic after augite; biotite in finely disseminated shreds and small crystals; sphene as ragged anhedral dustlike particles and as partial rims around titaniferous iron ore. Photomicrograph, pl. XI-2. Grain size: to 2 mm. Texture: micrographic and porphyritic.
12640-12650'
Cuttings
Mr-1-24

The thick sequence of perlites, tuffs, and devitrified glass in the Carlton Rhyolite Group in this well demonstrates an extrusive origin for all or a large part of the group. The well was drilled on outcrops of the Arbuckle Group in an area of the Arbuckle Mountains where the structure is homoclinal, so that the drilled thickness is within 10 percent of the stratigraphic thickness. The underlying granite is of the Wichita Granite Group and indicates widespread igneous activity, comparatively near the outcrop of the much older Tishomingo granite. The basic lithic fragment found in the lithic tuff at 7190-7200 feet may indicate the occurrence of spilitic lavas under the granitic rocks.

GEO. P. CAULKINS, 1 TURNER RANCH C NE NE 25-1S-4E (Mr-2)

Granite...... Microcline (36%), plagioclase (31%), quartz (22%), biotite (4%), chlorite (3%), sericite (2%), iron ore (1%), sphene (tr.), calcite (tr.), apatite (tr.), zircon (tr.). Quartz is large and partly strained; plagioclase contains cores more altered to sericite; biotite interlayered with alteration chlorite; clear microcline has poikilitically enclosed sericitized plagioclase. Grain size: to 3 mm. Texture: hypidiomorphic.
3344-3348'
Cuttings
Mr-2-1

Geo. P. Caulkins, 1 Turner Ranch (cont.)

Granite...... Microcline (35%), plagioclase (32%), quartz (21%), biotite (5%), sericite-clay (3%), chlorite (1%), iron ore (1%), epidote (tr.),
3348-3357' apatite (tr.), zircon (tr.). Fresh microcline has poikilitically
Cuttings enclosed plagioclase, highly altered to sericite and stained with
Mr-2-2 hematite; some minor myrmekitic intergrowth around edges of plagioclase; plagioclase somewhat zoned with sericitized cores; chlorite replaces biotite. Grain size: to 3 mm. Texture: hypidiomorphic.

This well penetrated normal granitic rock of the Eastern Arbuckle Province.

AMERADA, 1 HALE NE NW NE 19-2N-3E (Mr-3)

Granite...... Plagioclase (35%), microcline (29%), quartz (22%), biotite (5%), hornblende (4%), sphene (2%), iron ore (1%), epidote (1%), chlorite
6250-6260' (tr.), clay-zeolite-sericite (tr.), apatite (tr.). Plagioclase clouded
Cuttings with alterations, while microcline remains much more fresh;
Mr-3-1 larger quartz crystals are strained; sphene exceptionally well developed in euhedral wedge-shaped crystals; biotite and hornblende contain slight chloritic alterations; some breccia-reconstitution veins; small amounts of myrmekitic intergrowth. Grain size: to 3 mm and greater. Texture: hypidiomorphic

The rock is similar to other granites of this area and belongs to the Eastern Arbuckle Province. The high plagioclase content of this rock should place it in the quartz monzonite class, but with the relatively small cutting chips the composition of the slide is not necessarily representative of the true mode.

FRANKFORT, 1 FREEMAN HEIRS NW NE SE 1-1S-1W (Mr-4)

Rhyolite porphyry...... Phenocrysts: quartz (4%), perthite (4%); groundmass (92%): iron ore, plagioclase, calcite, chlorite, sericite, sphene.
4720-4730' Partly flow banded; small phenocrysts; amygdaloidal quartz is
Cuttings well developed and contains iron ore needles in exceptionally lacy
Mr-4-1 forms of inclusions with some hematite straining; groundmass is highly spherulitic and contains iron ore granules and abundant hematite dust; calcite, sericite, and quartz are in secondary veins and masses. Grain size: phenocrysts to 0.8 mm. Texture: porphyritic, spherulitic, and amygdaloidal.

Rhyolite porphyry...... Phenocrysts: perthite (5%), iron ore (2%); groundmass (93%): quartz, chlorite, sericite, zircon, calcite. Highly flow-
4770-4790' banded rhyolite contains small and poorly formed phenocrysts of
Cuttings perthite and some magnetite; bands are alternately spherulitic and
Mr-4-2 felsophyric, indicating compositional difference; bands are delicate, distorted around phenocrysts, and accentuated by iron ore dust. Grain size: phenocrysts to 0.8 mm. Texture: porphyritic, spherulitic, and felsophyric.

Rhyolite flow breccia...... Lithic fragments, feldspar, quartz, iron ore, sericite, chlorite, sphene, calcite. Diverse rhyolite fragments
4890-4900' are in a matrix of sericitic quartz-feldspar mosaic; matrix
Cuttings appears igneous as some flow lines are present; a few crystal
Mr-4-3 fragments of quartz and feldspar with lithic detritus. Grain size: to 4 mm. Texture: pyroclastic.

Frankfort, 1 Freeman Heirs (cont.)

Rhyolite porphyry...... Phenocrysts: perthite (12%), quartz (4%), iron ore (3%); groundmass (81%): sericite, chlorite, biotite, leucoxene, calcite,
4990-5010' apatite, zircon. Highly banded rhyolite with abundant local
Cuttings sericitization of feldspars; some biotite and chlorite in small
Mr-4-4 masses; perthite phenocrysts are embayed, quartz phenocrysts euhedral to embayed and shattered; banding delicate, delineated by iron ore dust trails as well as by bands having quartz or feldspar content. Grain size: phenocrysts to 2.5 mm. Texture: porphyritic and xenomorphic.

Rhyolite porphyry...... Phenocrysts: perthite (7%), quartz (6%), plagioclase (3%), iron ore (1%); groundmass (83%): sericite, calcite, chlorite,
5100-5200' leucoxene, zircon. Abundant groundmass recrystallization into
Cuttings optically continuous masses of quartz; small but numerous quartz
Mr-4-5 phenocrysts have optically continuous rims of surrounding groundmass quartz; dusty iron ore abundant in groundmass; calcite replaces ragged portions of the groundmass; relict patches of unaltered groundmass are much redder, with a felsophyric appearance. Grain size: phenocrysts to 2 mm. Texture: porphyritic, xenomorphic-micrographic, and relict felsophyric.

Saussurized diabase...... Plagioclase, saussurite, chlorite, iron ore, calcite, biotite, sphene-leucoxene, apatite. Saussurization nearly complete
5260-5295' with no twinning remaining in the plagioclase; apatite remains as
Cuttings needle inclusions; chlorite completely replaces former mafic
Mr-4-6 mineral; calcite as an irregular replacement; sphene-leucoxene as small granules. Grain size: relict laths to 1 mm. Texture: questionable.

Rhyolite porphyry...... Phenocrysts: perthite (7%), quartz (5%), iron ore (2%); groundmass (86%): chlorite, sericite, calcite, fluorite, biotite,
5520-5530' apatite, zircon. Perthite and quartz phenocrysts are set in a
Cuttings delicate but well-crystallized micrographic groundmass; the
Mr-4-7 normal size for micrographic units is 0.2 mm; calcite veins brecciate and invade irregularly; the micrographic groundmass suggests that this rock probably was intruded at depth as a sill within the volcanic sequence. Grain size: phenocrysts to 2 mm. Texture: micrographic and porphyritic.

Rhyolite porphyry...... Phenocrysts: perthite (8%), quartz (4%), iron ore (1%); groundmass (87%): chlorite, calcite, sericite, sphene, biotite,
5660-5680' apatite, zircon. Perthite phenocrysts are subhedral to rounded;
Cuttings quartz phenocrysts are smaller and are euhedral to subrounded;
Mr-4-8 some vague suggestion of spherulites present in groundmass; groundmass has spicular quartz needles optically continuous in several orientations; zircon associated with magnetite. Grain size: phenocrysts to 2 mm. Texture: porphyritic and spherulitic.

This well penetrated 1,030 feet of the Carlton Rhyolite Group before cutting through a thrust fault into Ordovician limestones. The lower samples of the rhyolite are rather coarse and are probably intrusive, whereas some of the higher rhyolites are undoubtedly extrusive. The well is located less than 2 miles north of rhyolite outcrop on the West Timbered Hills.

PONTOTOC COUNTY

GYPSY OIL CO., 1 EMERY SW NE NE 15-2N-6E (Pc-1)

Granite...... Microcline (40%), quartz (25%), oligoclase (15%), biotite (10%), iron ore (3%), chlorite (3%), sphene (2%), sericite (1%), apatite (tr.), zircon (tr.), calcite (tr.). Microcline contains patches of sericitized plagioclase; minor myrmekitic intergrowth present at the margins of the microcline; biotite is exceptionally well formed and contains inclusions of apatite and zircon, both with pleochroic halos; large quartz grains show straining; one chip has minor cataclastic lineation. Grain size: to 4 mm. Texture: hypidiomorphic.

6575-6595'
Cuttings
Pc-1-1

A normal granite of the Eastern Arbuckle Province located in the Franks graben. The well also contained an unsampled diabase cutting the granite.

ATLANTIC OIL CO., 1 HARVEY NW SE 27-3N-5E (Pc-2)

Granite...... Microcline (35%), quartz (32%), plagioclase (20%), biotite (5%), iron ore (3%), chlorite (2%), apatite (tr.), calcite (tr.), zircon (tr.), sphene-leucoxene (tr.), sericite (tr.). This granite shows extreme straining of all minerals, particularly quartz; relatively minor planes of slippage and reconstitution are present; microcline contains poikilitically enclosed quartz and plagioclase; pennine-type chlorite replaces portions of olive-green biotite, partly by interlayering; rare large apatite crystals associated with iron ore; biotite and iron ore have developed along slippage planes. Photograph of core, pl. XV-2; photomicrograph, pl. XVI-3. Grain size: to 3 mm. Texture: relict hypidiomorphic and cataclastic.

4800-4807'
Core
Pc-2-1

This granite of the Eastern Arbuckle Province shows extreme straining and cataclastic movement without mylonization and alteration. The well is the most northeasterly of all wells penetrating Eastern Arbuckle Province granite in southern Oklahoma.

G. P. CAULKINS, 1 NORRIS SW SE 27-1N-5E (Pc-3)

Granite porphyry(?)...... Microcline (42%), quartz (30%), plagioclase (13%), calcite (4%), chlorite (3%), feldspar alterations (3%), iron ore (3%), biotite (2%), zircon (tr.), apatite (tr.). Feldspars are turbid with alterations and hematite dust; twinning in microcline is delicate and poorly defined; plagioclase alteration advanced; exceptionally large phenocryst(?) of microcline contains poikilitically enclosed quartz and plagioclase; biotite altered to chlorite and associated calcite; brecciation and lineation common, with calcite and chertose quartz filling breccia seams. Grain size: to 6 mm. Texture: hypidiomorphic, porphyritic(?), and cataclastic.

3224-3232'
Cuttings
Pc-3-1

Iddingsite diabase...... Labradorite (55%), augite (23%), iddingsite (12%), iron ore (6%), chlorite (4%), apatite (tr.), zeolitic alterations (tr.). An exceptionally fresh diabase containing plagioclase that is nearly water clear; small amounts of chlorite developed at the margins of pale-brown augite; fibrous iddingsite as pseudomorphs after olivine. Grain size: to 0.7 mm. Texture: subophitic.

3232-3260'
Cuttings
Pc-3-2

These rocks of the Eastern Arbuckle Province were penetrated along the Hunton anticline. The fresh plagioclase in the diabase is in marked contrast to the altered granite and suggests it is of a younger age, after the granite had undergone cataclastic and hydrothermal alteration.

TEXFEL, 5 PATRICK $N\frac{1}{2}$ NE NE 31-2N-7E (Pc-4)

Granite...... Essential minerals are microcline, plagioclase, and quartz, accompanied by accessory biotite, hornblende, sphene, and magnetite, with traces of epidote, calcite, chlorite, apatite, and zircon. Feldspars generally fresh; biotite is in large olive-green books that contain pleochroic halos around zircon and apatite inclusions; minor chlorite interlayered with biotite; sphene is in large subhedral crystals; calcite occurs in thin veins; quartz grains generally are not strained; myrmekitic intergrowth locally developed on small scale. Grain size: to 3 mm. Texture: lypidiomorphic.

8770-8775'
Cuttings
Pc-4-1

A typical granite of the Eastern Arbuckle Province, similar to the Troy granite in outcrops of the Arbuckle Mountains.

STEPHENS COUNTY

CARTER OIL CO., 1 EVERETT WILLIFORD   C SE NE 24-2N-9W   (St-1)

Altered tuff...... Quartz, clay-sericite, sphene, pyrite, iron ore. Numerous holes in the slide probably represent clay-sericite masses destroyed during slide preparation; abundant quartz fragments are rounded to shard shaped; matrix is chertose quartz with some clay-sericite in association; masses of nearly pure sericite represent completely altered feldspar detritus; minor sphene and iron ore in cement. Grain size: phenocrysts to 1 mm. Texture: vitroclastic.
8537-8550'
Core
St-1-1

Rhyolite porphyry...... Phenocrysts: perthite (23%), chlorite (7%), quartz (5%); groundmass (62%): feldspar alterations (2%), calcite (1%), plagioclase, leucoxene, iron ore, zircon, apatite. High percentage of phenocrysts present; perthite contains abundant introduced chlorite and some patches of alteration clays; quartz phenocrysts are rounded and embayed; leucoxene replaces titaniferous iron ore granules; calcite is in veins and small replacement blebs; groundmass has the fuzzy appearance of devitrified glass. Grain size: phenocrysts to 3.5 mm. Texture: porphyritic and felsophyric.
9215-9242' top
Core
St-1-2

Lithic tuff...... Lithic fragments, chertose matrix, perthite, quartz, calcite, plagioclase, biotite, sphene-leucoxene, feldspar alterations. Lithic fragments are dominantly perlites set in a chertose matrix with gradational boundaries; perthite, quartz, and plagioclase are also found as detrital material, some with concave surfaces; perlite detritus high in biotite, serving to outline cracks; some lithic fragments appear chertose in origin; sphene-leucoxene as granular masses. Grain size: to 0.5 mm. Texture: fine-grained, pyroclastic.
9280-9290'
Cuttings
St-1-3

Rhyolite porphyry...... Phenocrysts: quartz (18%), perthite (7%); groundmass (73%): chlorite (2%), plagioclase, leucoxene, iron ore, feldspar alterations, apatite, zircon. Quartz phenocrysts are abundant, rounded to embayed; perthite contains abundant chlorite and a few zircon inclusions; groundmass is devitrified glass with poorly defined spherulites, vague in outline; iron ore mostly altered to leucoxene with sparse residual patches remaining. Grain size: phenocrysts to 3 mm. Texture: porphyritic and spherulitic.
9748-9773'
Core
St-1-4

Rhyolite porphyry...... Phenocrysts: perthite (11%), quartz (7%); groundmass (80%): chlorite (2%), leucoxene, plagioclase, iron ore, feldspar alterations, zircon, apatite. Groundmass is crudely banded, with some contortion around phenocrysts, and is composed of devitrified glass; banding appears to be mineralogic; the size of devitrified material differs from band to band; quartz is rounded and embayed; perthite contains chlorite as an introduced mineral; chlorite also as pseudomorphic masses in the groundmass. Grain size: phenocrysts to 2.5 mm. Texture: porphyritic and felsophyric.
9773-9782'
Core
St-1-5

Green shale...... Clay-micas, quartz, iron ore, feldspar. This rock looks suspiciously like a lower Paleozoic shale; mica orientation parallel with prominent lamination; recognizable detritus limited to quartz and chalcedonic quartz; reconstitution is incipient at best; this may be a fault slice of Paleozoic shale and is unique when compared with other basement rocks. Grain size: to 0.05 mm to submicroscopic. Texture: clastic.
9799-9801'
Core
St-1-6

Carter Oil Co., 1 Everett Williford (cont.)

Spilite...... Plagioclase (49%), chlorite (31%), calcite (10%), sphene (5%), feldspar alterations (3%), iron ore (2%), apatite (tr.). Slender laths of albite (An_6) are generally fresh; former pyroxene is completely altered to chlorite in very fine aggregates of shreds; skeletal iron ore surrounded by sphene; calcite in irregular veins and replacement masses. Photomicrograph, pl. XII-2. Grain size: to 0.4 mm. Texture: relict subophitic.
10026-10029'
Core
St-1-7

Spilite...... Plagioclase (40%), sphene-leucoxene-epidote (15%), chlorite (35%), feldspar alterations (9%), garnet (1%), iron ore (tr.), quartz (tr.). Fine splintery lath of albite (An_{5-9}), altering to a clay mineral; chlorite replaces former pyroxene and is generally intergranular to the albite laths; sphene-leucoxene is abundant as poorly crystalline granular masses; epidote as replacement mass associated with chlorite and minor garnet; tiny crystals of garnet in "trails" associated with a minor vein quartz. Grain size: 0.1 mm. Texture: relict subophitic.
10139-10146'
Core
St-1-8

This well penetrated a most unusual sequence of rocks. The rhyolites of the Carlton Rhyolite Group contain a higher percentage of phenocrysts than any other sequence of rhyolites examined and are generally similar through a long sequence in a volcanic suite characterized elsewhere by diversity. The green shale at 9,799-9,801 feet is unlike any argillite found in the basement rock of southern Oklahoma. The green waxy color and prominent lamination suggests it is a fault slice of a lower Paleozoic shale. The well was drilled in a structurally complex area that bounds the north side of the Wichita-Criner axis, where faulting of great magnitude may be demonstrated in the immediate vicinity. The absence of granitic rocks under the volcanic suite suggests that the rhyolite and spilite are in fault contact. The spilite of this well is in the Navajoe Mountain Basalt-Spilite Group and is correlated with the thick basalt-spilite lava sequence found in the Stanolind, 1 Perdasofpy (Cm-1) to the northwest. The only cores of spilite in southern Oklahoma available to us are from the Williford well. About 178 feet of the spilitic lavas were penetrated. The rock overlying the basement and below typical Reagan Sandstone appears similar to the maroon and green upper Paleozoic shales and may have a tectonic explanation or be an unusual phase of the Reagan Sandstone.

For chemical analysis of spilite core from 10,136 to 10,139 feet, see table 18.

CARTER, 1 EMMONS   C SE NE 25-2N-9W   (St-2)

Rhyolite porphyry...... Plagioclase phenocrysts (6%); groundmass (94%): potash feldspar, quartz, siderite, chlorite, iron ore, sphene-leucoxene, feldspar alterations, zircon, apatite. Good primary spherulites have a partial radial structure around phenocrysts; phenocrysts are glomeroporphyritic, containing as many as five optic units; these complex phenocrysts are associated with sphene-leucoxene and chlorite; siderite highly stained with hematite. Grain size: phenocrysts to 1 mm. Texture: porphyritic and spherulitic.
6500-6510'
Cuttings
St-2-1

Rhyolite porphyry...... Plagioclase phenocrysts (8%); groundmass (92%): potash feldspar, quartz, amphibole(?), siderite, calcite, chlorite, iron ore, sphene-leucoxene, zircon, apatite. Broad crudely defined flow bands caused by mineral inhomogeneity; spherulites developed in some bands; phenocrysts are large and somewhat embayed; spherulites have pale-brown core and a deeper reddish rim; siderite is stained with hematite and associated with common calcite; amphibole(?) concentrated in bands as small and ill-defined crystals. Grain size: phenocrysts to 2.5 mm. Texture: porphyritic and spherulitic.
7050-7060'
Cuttings
St-2-2

Carter, 1 Emmons (cont.)

Rhyolite porphyry...... Phenocrysts: albite (14.8%), iron ore (1.7%), biotite-chlorite (2.4%); groundmass (80%): potash feldspar, quartz,
7227-7229' calcite, chlorite, siderite(?), feldspar alterations, zircon.
Core Groundmass highly stained with hematite dust and is delicately
St-2-3 spherulitic with abundant spicular quartz; sodic oligoclase phenocrysts are composite optic units with a rounded exterior form; calcite replaces irregularly in groundmass and phenocrysts; chlorite and siderite(?) have heavy hematite stain. Grain size: phenocrysts to 4 mm. Texture: porphyritic and spherulitic.

Rhyolite porphyry...... Plagioclase phenocrysts (5%); groundmass (91%): chlorite (2%), calcite (2%), potash feldspar, quartz, iron ore,
7341-7345' feldspar alterations, sphene-leucoxene, apatite, zircon. Finely
Core spherulitic groundmass contains abundant spicular quartz; calcite
St-2-4 and chlorite in association as late masses; plagioclase phenocrysts slightly altered and contain iron ore dust causing a reddish color; some phenocrysts are composite optic units and are partly embayed by chloritic material. Grain size: phenocrysts to 3 mm. Texture: porphyritic and spherulitic.

This sequence of rocks of the Carlton Rhyolite Group shows a great diversity of textures and megascopic characteristics. The type of rhyolite found in this well is generally dissimilar to that in the Carter, 1 Williford (St-1), drilled a mile southwest. For chemical analysis of rhyolite core at 7,227-7,229 feet, see table 18. A Sr/Rb isotopic whole-rock age was determined on a core from 7,227 to 7,229 feet to be 510 ± 90 million years.

PIERCE, 1 COUCH NE NE SE 34-2N-9W (St-3)

Rhyolite porphyry...... Phenocrysts: plagioclase (8%), perthite (7%), iron ore (1%); groundmass (84%): quartz, calcite, chlorite, feldspar
3840-3850' alterations, sphene-leucoxene, biotite, apatite. Wormy and
Cuttings embayed perthite phenocrysts present with subhedral to euhedral
St-3-1 plagioclase; groundmass is highly spherulitic, with relatively minor interspherulitic material, higher in iron ore dust; chlorite as replacement masses and veins as well as disseminated shreds; granular masses of poorly crystalline sphene-leucoxene are associated with chlorite and are also discrete in groundmass; spherulites are radial around phenocrysts; former mafic rods parallel to radial spherulites now altered to chlorite and iron ore. Grain size: phenocrysts to 1 mm. Texture: porphyritic and spherulitic.
A normal rock of the Carlton Rhyolite Group.

CALIFORNIA CO., 1 KETCHUM SW NE SW 3-1N-9W (St-8)

Rhyolite porphyry...... Potash feldspar, quartz, plagioclase, iron ore, siderite, feldspar alterations, chlorite, sphene-leucoxene, calcite, apatite,
3610-3625' zircon. Highly spherulitic and micrographic groundmass has
Cuttings poorly defined mineral boundaries; phenocrysts of quartz are
St-8-1 sparse, and feldspar phenocrysts are almost too altered and stained with hematite to distinguish from feathery spherulites; siderite with a limonitic stain replaces irregularly in the groundmass; micrographic intergrowth locally well developed and relatively coarse; sericite replaces some feldspars. Grain size: phenocrysts to 0.8 mm. Texture: porphyritic, spherulitic, and micrographic.
The siderite found in this rhyolite seems to characterize much of the basement rock of this general area. In grain size the rhyolite is comparatively coarse, and perhaps it is an intrusive phase of the Carlton Rhyolite Group.

TRAVIS HEDGE, 1 ROARK NW SE NE 3-1N-9W (St-9)

Rhyolite porphyry...... Feldspar, quartz, iron ore, calcite, siderite, plagioclase, feldspar alterations. Lack of accessory mineral is
3250-3260' a striking feature; plagioclase phenocrysts are exceedingly sparse;
Cuttings groundmass is devitrified glass with fuzzy mineral boundaries;
St-9-1 suggestion of spherulites in groundmass; calcite associated with iron-stained siderite; some amygdule forms contain optic units of pure(?) quartz. Grain size: phenocrysts to 0.6 mm. Texture: porphyritic, spherulitic, and felsophyric.
A devitrified glassy flow rock of the Carlton Rhyolite Group.

W. B. CLEARY, 1 ING NW NW SE 7-1N-8W (St-11)

Diabase...... Plagioclase (44%), chlorite (27%), calcite (10%), iron ore (11%), pyroxene (6%), feldspar alterations (2%), apatite. Brownish
4730-4737' clouded pigeonitic pyroxene altering to chlorite contains some
Cuttings calcite replacement; labradorite is generally fresh but contains
St-11-1 small cracks and patches of replacement calcite; one small mass of finer grained basaltic material may be chilled marginal phase as an inclusion. Grain size: to 0.8 mm. Texture: ophitic to subophitic.
This well penetrated rock interpreted as a diabasic intrusion into the Carlton Rhyolite Group.

LONE STAR PRODUCING CO., 1 RETHA BEAVERS SW NW SW 24-1S-7W (St-12)

Rhyolite porphyry...... Plagioclase phenocrysts (11%); groundmass (89%): potash feldspar, quartz, siderite, clay-sericite, iron ore,
11,565½' cir. sphene-leucoxene, calcite, apatite, zircon. Relict spherulitic
Cuttings groundmass is invaded by finely granular siderite; oligoclase
St-12-1 phenocrysts contain apatite needles and are associated with iron ore relicts altered to sphene-leucoxene; calcite replaces minor portions of the phenocrysts; siderite is iron stained; clay-sericite has replaced feldspars extensively in groundmass. Grain size: phenocrysts to 2 mm. Texture: porphyritic and spherulitic.
This well is geographically located approximately halfway between the Wichita Mountains and the Criner Hills, and helps to demonstrate that the basement rock underlying Reagan Sandstone of this broad area is rhyolite of the Carlton Group.

JONES OIL CO., 9 FURST NE SE NW 16-1S-8W (St-13)

Rhyolite porphyry...... Phenocrysts: perthite (8%), quartz (3%), leucoxene (1%); groundmass (88%): calcite, iron ore, feldspar alterations,
8720-8740' chlorite, dolomite(?), apatite, zircon. Delicate spherulites are
Cuttings present in the groundmass; quartz phenocrysts are rounded and
St-13-1 embayed and smaller than perthite phenocrysts; perthite phenocrysts highly clouded by iron ore dust and alterations; leucoxene as pseudomorphs after titaniferous magnetite; carbonate (dolomite?) as discrete perfect rhombs in groundmass; chlorite exceptionally rare. Grain size: phenocrysts to 1.5 mm. Texture: porphyritic and spherulitic.
The Reagan Sandstone overlying the rhyolite produced oil for a time as the first Reagan production in Oklahoma. The basement rock is a representative of the Carlton Rhyolite Group.

TILLMAN COUNTY

J. K. WADLEY ET AL., 1 CAPPS NW NW SW 10-1N-18W (Ti-4)

800-810'
Cuttings
Ti-4-1

Meta-graywacke...... Quartz, biotite, feldspar, lithic fragments, epidote, iron ore, apatite, zircon. Subrounded to angular fragments are set in a matrix of chertose quartz mosaic with porphyroblastic small biotite crystals; lithic fragments include cherts, metacherts, quartzite, and fragments of granitic origin; feldspar appears to be mostly plagioclase; both apatite and zircon are large but sparse detrital grains. Grain size: to 0.5 mm, 0.15 mm average. Texture: clastic-granoblastic.

900-910'
Cuttings
Ti-4-2

Meta-graywacke and meta-graywacke silt...... Quartz, feldspar, biotite, lithic fragments, epidote, calcite, iron ore, apatite, garnet. Basically similar to the previous sample; chertose quartz with crystalloblastic reddish olive-green biotite and minor epidote compose the matrix; feldspar appears to be mostly plagioclase and is highly altered to sericite; garnet appears to be detrital; lithic fragments include phyllites, quartzite, chert, and fragments of granitic origin; the more silty chips contain much more biotite. Grain size: to 0.7 mm and 0.05 mm. Texture: clastic-granoblastic.

The original rock appears to have been a graywacke with clay matrix interbedded with silty or shaly layers. The clay has been reconstituted into a quartz-biotite mosaic. The detrital grains are marginally frayed but otherwise unchanged. A common rock of the Tillman Metasedimentary Group.

J. BEN. RUSSELL, 1 MARVIN GOODWIN SE SE NW 21-1N-17W (Ti-12)

1085-1133'
Cuttings
Ti-12-1

Meta-graywacke...... Quartz, feldspar, biotite, amphibole, chlorite, calcite, sphene-leucoxene, apatite, zircon, hematite. Fragments of quartz and feldspar are enclosed in a matrix of chertose quartz and crystalloblastic biotite and minor amphibole; biotite altering to a pennine-type chlorite, with sphene developed as a secondary mineral; calcite as minor veins; several composite quartz fragments are possibly quartzitic in origin; amphibole is mildly pleochroic and weakly birefringent; feldspars sericitized in part and stained with hematite. Grain size: 0.4 mm average. Texture: clastic-granoblastic.

In texture, mineralogy, and grade of metamorphism the rock is a typical meta-graywacke of the Tillman Metasedimentary Group.

For chemical analysis of this rock see table 18.

HONOLULU OIL CORP., 1 BURBA NE NE NE 33-1N-17W (Ti-13)

2480-2500'
Cuttings
Ti-13-1

Meta-graywacke...... Quartz, feldspar, lithic fragments, biotite, amphibole, sphene-leucoxene, iron ore, pyrite, apatite, zircon. Lithic and mineral fragments are in a matrix of chertose quartz and crystalloblastic biotite; lithic fragments include quartzite, biotite-quartz schist, lineated chert, and fragments of granitic origin; fragments are subrounded to angular; amphibole is a minor crystalloblastic mineral; no reconstitution of mineral fragments, only matrix seems affected by metamorphism. Grain size: 0.5 mm. Texture: clastic-granoblastic.

Honolulu Oil Corp., 1 Burba (cont.)

2540-2550'
Cuttings
Ti-13-2

Meta-graywacke...... Quartz, feldspar, lithic fragments, biotite, chlorite, muscovite, epidote, iron ore, calcite, apatite, sphene-leucoxene. Biotite concentrated along detrital grain margins in a chertose quartz matrix; hematite stains biotite locally; feldspar fragments include perthite, plagioclase, orthoclase, and microcline; lithic fragments are mostly diverse schists and cherts; minor marginal reconstitution of detrital grains at boundaries with matrix. Grain size: 0.4 mm average. Texture: clastic-granoblastic.

2620-2630'
Cuttings
Ti-13-3

Meta-graywacke...... Quartz, feldspar, biotite, lithic fragments, amphibole, muscovite, sphene-leucoxene, feldspar alterations, apatite, zircon, iron ore. Similar to previous sample; muscovite as crystalloblastic shreds with biotite; biotite appears to be concentrated near detrital margins and invades grain edges in slight reconstitution; fragments are subrounded to angular. Grain size: 0.5 mm average. Texture: clastic-granoblastic.

2680-2690'
Cuttings
Ti-13-4

Meta-graywacke...... Quartz, feldspar, lithic fragments, biotite, epidote, chlorite, pyrite, iron ore, apatite, zircon(?). Some chips contain less biotite with an attendant increase in an iron-poor variety of epidote; one chip appears to contain a relict eye in a lineated fine-grained biotite-rich matrix; the eye is a normal meta-graywacke and is probably a cataclastic relict; most lithic fragments are cherts or metacherts; some chips contain high hematite stain, with biotite altering to chlorite and associated hematite. Grain size: 0.4 mm average. Texture: clastic-granoblastic.

2760-2770'
Cuttings
Ti-13-5

Meta-graywacke...... Quartz, feldspar, biotite, lithic fragments, amphibole, chlorite, epidote, sphene-leucoxene, iron ore, apatite, pyrite(?). Chips differ considerably in mineral composition; pale-green amphibole takes the place of biotite in some chips; epidote as minor crystalloblastic mineral; matrix contains hematite staining and may be relatively high in feldspar; magnetite of questionable origin; lithic fragments are mostly quartzose. Grain size: 0.3-0.4 mm average. Texture: clastic-granoblastic.

Tillman Metasedimentary Group. The relative uniformity of the rock found in the well both in mineralogy and grade of metamorphism is an outstanding feature. The occurrence of small amounts of amphibole in the lower portion of the sequence indicates a slightly higher rank of metamorphism. The detrital grains are only marginally sutured whereas the original matrix, assumed to be clay, has been reconstituted entirely to biotite in a chertose mosaic of quartz, with perhaps some feldspar. Lineation is vague or absent, indicating essentially an unstressed metamorphic environment.

BUEL & HERDON, 1 HAUGHT SE SE NE 22-1N-16W (Ti-15)

790-795'
Cuttings
Ti-15-1

Meta-basalt porphyry...... Plagioclase, iron ore, biotite, calcite, chlorite, plagioclase alterations. Relict phenocrysts of plagioclase (An_{53}) altered to minor sericite-clay; calcite as finely disseminated specks in groundmass and invading phenocrysts; extremely fine-grained iron ore in groundmass; chlorite as vug replacement associated with some iron ore; groundmass is composed of biotite shreds and some low-birefringent material, possibly plagioclase or a zeolite. Grain size: phenocrysts to 2 mm. Texture: relict porphyritic and granoblastic.

Buel & Herdon, 1 Haught (cont.)

Meta-basalt porphry...... Plagioclase, iron ore, biotite, chlorite, pyroxene, amphibole, quartz, plagioclase alterations. Low-rank metamorphosed basaltic lava; phenocrysts of sodic labradorite altering to sericite set in a fine-grained reconstituted groundmass of plagioclase and alterations, with tiny iron ore granules and abundant shreds of biotite; the groundmass plagioclase appears to be more sodic, perhaps andesine; small relicts of augite, altering to uralitic hornblende; iron ore enriched irregularly along linear trends; quartz as secondary veins and vug fillings with chlorite and biotite. Grain size: phenocrysts to 1.5 mm, groundmass 0.06 mm average. Texture: porphyritic and granoblastic.

815-833'
Cuttings
Ti-15-2

These basaltic lavas are part of the Navajoe Mountain Basalt-Spilite Group. The grade of metamorphism here is low, perhaps incipient. The basic hornfels found as basement rock in the Young, 1 Cook (Kw-49), a few miles to the north, probably originated from basaltic lavas of this type.

MID CONTINENT, 1 PERRY SE SE SW 30-1S-16W (Ti-18)

Meta-graywacke...... Quartz, feldspar, lithic fragments, biotite, amphibole, pyrite, sphene-leucoxene, iron ore, apatite. Lithic fragments include cherts, metacherts, schists, quartzites, and detritus of granitic origin; crystal and lithic fragments are in a matrix of chertose mosaic quartz with crystalloblastic olive-green biotite and pale-green amphibole; titaniferous iron ore and sphene-leucoxene are in a microgranular association; detrital grains slightly sutured at margins; biotite is concentrated at margins and outlines grain boundaries. Photomicrograph, pl. XIV-1. Grain size: 0.4 mm average. Texture: clastic-granoblastic.

1490-1500'
Cuttings
Ti-18-1

Meta-graywacke grading to hornfels...... Quartz (20%), biotite (28%), potassium feldspar (19%), epidote (11%), plagioclase (8%), muscovite (2%), calcite (1%), iron ore (tr.), sphene-leucoxene (tr.), calcite (tr.), apatite (tr.). Mode represents more highly metamorphosed chips; relict clastic texture is well defined in some chips and absent in others; large crystalloblastic muscovite formed; epidote is abundant in more highly metamorphosed areas; no recognizable alignment of micas; hematite as intergranular stain, no other iron ore present, but sphene-leucoxene may be after titaniferous magnetite. Grain size: to 0.6 mm. Texture: relict clastic to granoblastic.

1560-1570'
Cuttings
Ti-18-2

Mica-quartz hornfels...... Quartz (42%), feldspar (28%), biotite (14%), epidote (12%), muscovite (2%), chlorite (1%), iron ore (1%), sphene-leucoxene (tr.), amphibole (tr.), topaz(?) (tr.), apatite (tr.). No fragmental outlines remain, owing to secondary crystalloblastic growth; one chip has a large epidote crystal, the others have olive-green biotite associated with muscovite; feldspars are kaolinized and partly sericitized; pale-green amphibole is in small crystalloblastic crystals. Grain size: to 0.8 mm variable. Texture: granoblastic.

1600-1610'
Cuttings
Ti-18-3

Amphibole hornfels...... Amphibole (42%), feldspar (26%), quartz (18%), biotite (11%), sphene (1%), iron ore (1%), feldspar alterations (tr.), epidote (tr.), chlorite (tr.), apatite (tr.). Large crystalloblastic pale-green tremolitic amphibole is set in a quartz-feldspar mosaic; olive-green biotite is associated with amphibole; epidote as small grains; sphene as a total rim around titaniferous iron ore; sericite is the main alteration of feldspars; biotite appears to represent incomplete amphibole conversion rather than retrograde metamorphism. Grain size: 0.3 mm average, 0.9 mm maximum. Texture: granoblastic. Photomicrograph, pl. XIV-2.

1720-1740'
Cuttings
Ti-18-4

Mid Continent, 1 Perry (cont.)

This is one of the more important wells in the Tillman Metasedimentary Group, because it shows progressive downward-increasing metamorphic effects in the comparatively short vertical distance of only 257 feet. The effects are those of a contact hornfels, believed to have been caused by the intrusion of Wichita granite at a relatively shallow depth, below the bottom samples of this well.

The progressive conversion of the meta-graywacke into hornfels also demonstrates the probable origin of some of the higher rank metamorphic rocks found within the Tillman Group of southern Oklahoma.

CONTINENTAL, 1 J. M. SMITH NW SE 6-2S-16W (Ti-20)

Meta-graywacke...... Detrital grains (75%): quartz (35%), feldspars (20%), lithic fragments (20%); matrix (25%): biotite, quartz, feldspar, epidote, muscovite, sphene, pyrite. An etched and stained slide of this core indicates an exceptionally low potash feldspar content with abundant untwinned oligoclase (An_{11}); matrix is a quartzose mosaic with crystalloblastic olive-green biotite; sphene is in small discrete granules; lithic fragments are largely quartzose but schistose grains are noted; poor sorting of detritus. The rock is a medium-grained meta-graywacke. Photomicrograph, pl. XIV-5, 6. Grain size: to 1.3 mm, 0.4 mm average. Texture: clastic-granoblastic.

3325-3341'
Core
Ti-20-1

This rock is a normal meta-graywacke of the Tillman Metasedimentary Group. The core is the only one of meta-graywacke obtained from southern Oklahoma.

SUN DRLG. CO. (BATSON), 1 PARKS SW SW SW 11-2S-16W (Ti-21)

Mica schist cut by granite...... Feldspar (40%), quartz (28%), biotite (17%), chlorite (7%), iron ore (3%), muscovite (2%), sericite (1%), sphene (tr.), apatite (tr.). Mode represents only schist portion of this interval; feldspar is sericitized and stained with hematite; biotite is altered to chlorite; granite cutting the schist is quite coarse and contains biotite identical to that in the schist; thin quartz veins cut schist; muscovite as minor crystalloblastic crystals, associated with biotite; micas show excellent alignment; high feldspar content indicates original rock was feldspathic and perhaps a graywacke. Grain size: in granite to 4 mm, in schist 0.15 mm average. Texture: lepidoblastic in schist and hypidiomorphic in granite.

1940-1950'
Cuttings
Ti-21-1

Biotite schist and amphibole schist...... Quartz (41%), feldspar (35%), biotite (8%), amphibole (6%), calcite (4%), muscovite (3%), chlorite (2%), hematite (1%). Chips differ greatly in mineralogic percentages; chips containing abundant amphibole have a much lesser percentage of quartz and feldspar; amphibole is altered greatly, with calcite in intimate association; hematite as blebs staining mafic minerals; the two types are probably phases of the same rock, possibly interlayered. Grain size: to 0.5 mm. Texture: lepidoblastic.

1960-1970'
Cuttings
Ti-21-2

The original rock is interpreted as a graywacke of the Tillman Metasedimentary Group, and the metamorphism is probably related to the intrusion of Wichita granite, as represented in the upper cuttings. Compare also the Ray, 1 Madison (Ti-22) in the same section.

R. O. RAY ET AL., 1 MADISON NW NW NW 11-2S-16W (Ti-22)

Biotite schist cut by granite...... Feldspar, quartz, biotite, muscovite, iron ore, sphene-leucoxene, calcite, microcline, lithic fragments.

1870-1894'
Cuttings
Ti-22-1

Chips are small and the textural relations obscure; granite appears to be a rather coarse two-feldspar granite carrying microcline in minor amounts and containing well-developed biotite; schist is high in feldspar and has a relict clastic texture, poorly preserved in some chips; biotite subaligned and well crystallized in schist. Grain size: greater than 1.4 mm in granite, 0.6 mm average in schist. Texture: relict clastic, lepidoblastic in schist and hypidiomorphic in granite.

The schist appears to be derived from a graywacke or arkose, and probably is an example of the more complete reconstitution of rocks in the Tillman Metasedimentary Group.

The microcline granite that cuts the schist is exceptional, as other granites found in this area contain perthite as the normal potash feldspar. The chips are quite small and it is therefore difficult to determine the precise character of the granite, although it is interpreted as belonging to the Wichita Granite Group.

MID CONTINENT, 1 OVERTON NW NE NW 33-1S-16W (Ti-35)

Biotite schist...... Quartz (39%), biotite (32%), feldspar (27%), iron ore (1%), apatite (tr.), calcite (tr.), feldspar alterations (tr.). Strongly

1670-1690'
Cuttings
Ti-35-1

lineated olive-green fresh biotite in a granoblastic mosaic of quartz and feldspar; feldspar appears to be mostly clear plagioclase with small amounts of clay and sericitic alterations; apatite as numerous stubby crystals in quartz and feldspar; calcite as secondary replacement. Photomicrograph, pl. XIV-4. Grain size: 0.2 mm average. Texture: lepidoblastic.

Muscovite schist...... Quartz, feldspar, iron ore, muscovite, chlorite, epidote, apatite. This rock was originally a biotite-muscovite schist in

1700-1710'
Cuttings
Ti-35-2

which the biotite has been altered to hematite with relict chlorite remaining; muscovite well developed and lineated; feldspars are water clear and virtually undistinguishable from quartz. Grain size: 0.2 mm average. Texture: lepidoblastic.

Epidote-muscovite hornfels...... Quartz, feldspar, muscovite, epidote, biotite, chlorite, iron ore, calcite, apatite, garnet, feldspar alterations,

1710-1720'
Cuttings
Ti-35-3

tourmaline. The first four listed minerals constitute at least 95 percent of the slide; feldspar is water clear and untwinned with only sparse alterations, usually along linear bands of high mica-epidote content; smoky-blue tourmalines are sparse; muscovite flakes are generally small and are carried by quartz and feldspar as inclusions; quartz-feldspar boundaries highly sutured; epidote as subhedral to euhedral crystals in groups and linear trends; small biotite crystals are general intergranular; garnet occurs sparsely as idioblastic dodecahedrons and rounded small crystals. Grain size: 0.2 mm average. Texture: granoblastic.

An unusual well in the Tillman Metasedimentary Group because of the relatively high grade of metamorphism and the rapid change in the type of rock. The first two studied thin sections are closely allied, the only essential difference being the alteration of biotite and the addition of relatively minor muscovite. Only 10 feet vertically away the mica content is decreased and the ratio of muscovite to other mica is greatly increased. The occurrence of tourmaline, even in small amounts, is exceptional. Geographically the well is located approximately half way between the normal meta-graywacke found in the Continental, 1 Smith (Ti-20) and the biotite schist in the Sun (Batson), 1 Parks (Ti-21).

LIPPERT, 1 MILLER SE SW SW 19-2N-17W (Ti-37)

Quartz diorite...... Andesine (55%), amphibole (16%), iron ore (11%), quartz (6%), chlorite (4%), calcite (3%), biotite (1%), zeolite (1%),

590'
Core
Ti-37-1

pyroxene (1%), topaz(?) (1%), sphene (tr.), potash feldspar (tr.), fluorite (tr.). Long laths of andesine (An_{45}) with intergranular uralitic hornblende, common primary hornblende, and tremolitic hornblende; minor chlorite alteration associated with relicts of pyroxene; calcite veins subparallel; pneumatolytic minerals, topaz and fluorite, are intergranular; quartz and a micrographic quartz feldspar intergrowth are present. Grain size: to 4 mm. Texture: hypidiomorphic.

The diorite found in this well is tentatively placed with the Raggedy Mountain Gabbro Group as a relatively acid differentiate. The normal granite of the Wichita Mountains crops out a little over a mile to the north of this location.

ALLEN & TREADWELL, 1 HOWELL SW SW NE 13-1N-17W (Ti-38)

Micrograbbro...... Plagioclase (59%), pyroxene (17%), zeolite (12%), iron ore (8%), biotite (2%), basaltic hornblende (1%), chlorite (1%), acicular

595-600'
Cuttings
Ti-38-1

inclusions (tr.). Exceptionally diverse in texture and grain size; one chip is xenomorphic granular plagioclase, pyroxene, and iron ore, all about 0.5 mm in diameter; other chips have ophitic pyroxene with small enclosed bytownite (An_{72}) laths; zeolite veins are common but feldspar is fresh; basaltic hornblende as fine rim around iron ore. Grain size: from 2 mm to 0.5 mm. Texture: xenomorphic to ophitic to hypidiomorphic.

Gabbro...... Plagioclase (58%), pyroxene (26%), olivine (8%), iron ore (3%), biotite (2%), basaltic hornblende (1%), tremolitic amphibole (1%),

670-683'
Cuttings
Ti-38-2

chlorite (1%), zeolite (tr.), sphene (tr.), zircon (tr.). Exceptionally large subhedral orthopyroxene with a rim of thin clinopyroxene; clinopyroxene contains some schiller iron ore; sodic bytownite (An_{70}) as subhedral laths and rounded grains poikilitically enclosed in pyroxene; large biotite contains one zircon with a pleochroic halo, very unusual in a rock this basic in composition. Grain size: to 1.5 mm. Texture: hypidiomorphic and poikilitic.

Gabbro...... Plagioclase (53%), pyroxene (31%), iron ore (11%), biotite (2%), apatite (2%), amphibole (1%), acicular inclusions (tr.). Labrador-

810-820'
Cuttings
Ti-38-3

ite contains unidentified dustlike inclusions; pyroxene is mostly granular and is associated with small amounts of biotite; apatite is exceptionally large; pyroxene contains some schiller iron ore. Grain size: to 2.5 mm. Texture: hypidiomorphic.

The gabbroic rocks found in this well are examples of the Raggedy Mountain Gabbro Group and represent one of the few penetrations of gabbroic rock south of the Wichita Mountains. The diverse textural differences may indicate an environment such as is found near the margins of intrusions.

The rock into which the gabbro was intruded is probably that of the Tillman Metasedimentary Group, which is the normal basement rock immediately to the south.

WASHITA COUNTY

OKLAHOMA MIDWEST, 1 DOCK SW SW SW 21-8N-18W (Wt-1)

Altered rhyolite porphyry...... Feldspar, quartz, clay-sericite, iron ore, chlorite, calcite, leucoxene, apatite. Some spherulitic suggestion in the least altered portion of groundmass; most altered portions contain clay-sericite after feldspar with optically continuous areas of discrete quartz; rare phenocryst relicts of plagioclase, most phenocrysts having been replaced by clay-sericite with minor chloritic micas. Grain size: relict phenocrysts to 1 mm. Texture: relict porphyritic and relict spherulitic.

2770-2778'
Cuttings
Wt-1-1

The advanced alteration of the feldspars to clay-sericite seems to characterize this area of rhyolite; the Shell, 1 Galloway (Wt-2) contains rocks that are similarly altered. The rocks of this well are allied to the Carlton Rhyolite Group.

SHELL, 1 GALLOWAY SE SE SE 21-8N-18W (Wt-2)

Andesite(?) porphyry...... Plagioclase (63%), chlorite (20%), sphene-leucoxene (8%), calcite (4%), clay-zeolite (3%), iron ore (2%), apatite (tr.). Sodic andesine with alterations of clay-zeolite; chlorite is intergranular and is in masses of low birefringent shreds; most iron ore altered to sphene-leucoxene; calcite replaces irregularly; this lava or dike rock has an exceptional composition as compared with rocks of the rhyolitic group or younger diabase dikes. Grain size: to 3 mm. Texture: porphyritic and intergranular.

2200-2220'
Cuttings
Wt-2-1

Rhyolite porphyry...... Feldspar, quartz, sericite-clay, chlorite, iron ore, zeolite, zircon. Large well-developed spherulites with some core phenocrysts of feldspar; spherulites have highly colored inner cores of spherulitic quartz-feldspar and clear outer rims containing iron ore dust; small cracks filled with zeolite; chlorite is interspherulitic, in a quartz-feldspar mosaic. Grain size: phenocrysts to 0.3 mm. Texture: porphyritic and spherulitic.

2280-2300'
Cuttings
Wt-2-2

Rhyolite porphyry...... Clay-sericite, quartz, potash feldspar, plagioclase, chlorite, iron ore, sphene-leucoxene, calcite, zircon, apatite. Plagioclase phenocrysts almost completely replaced by clay-sericite; groundmass appears relict spherulitic with coarser interspherulite material; much of groundmass feldspar has been replaced by clay-sericite; iron ore granules altering to sphene-leucoxene with associated zircon. Grain size: relict phenocrysts to 2 mm. Texture: relict porphyritic and spherulitic.

2750-2780'
Cuttings
Wt-2-3

Rhyolite porphyry...... Plagioclase phenocrysts (2%), groundmass (98%), potash feldspar, quartz, clay-sericite, calcite, chlorite, iron ore, sphene-leucoxene, zircon. Groundmass relict spherulitic with irregular linear trends of coarse quartz; plagioclase phenocrysts sparse and replaced by clay-sericite; clay sericite locally dominates the groundmass; zircon somewhat metamict. Grain size: phenocrysts to 0.7 mm. Texture: porphyritic and spherulitic.

2910-2920'
Cuttings
Wt-2-4

Agglomerate(?) or rhyolite porphyry with tuff...... Phenocrysts: plagioclase (3%), quartz (1%); groundmass (96%): clay-sericite, potash feldspar, calcite, chlorite, sphene-leucoxene, iron ore. This rock is either a coarse agglomerate with fragments greater in size than the chips, or a thin-layered rhyolite and tuff; phenocrysts are sparse; calcite replaces portions of the rock in finely granular masses and in crystalline veins; feldspars much altered to clay-sericite. Grain size: phenocrysts to 2 mm. Texture: porphyritic and relict spherulitic or clastic.

3100-3110'
Cuttings
Wt-2-5

Shell, 1 Galloway (cont.)

Perlitic rhyolite porphyry...... Plagioclase phenocrysts (6%); groundmass (94%): potash feldspar, quartz, clay-sericite, calcite, sphene-leucoxene, iron ore. Completely devitrified groundmass with faint but well-defined perlitic cracks; much clay-sericite replacement of feldspars; cores of perlites appear susceptible to calcite replacement; large iron ore granules altered to sphene-leucoxene; hematite as dust in groundmass; minor quartz veins present. Grain size: phenocrysts to 1.4 mm. Texture: perlitic and glomeroporphyritic.

3380-3390'
Cuttings
Wt-2-6

Welded rhyolite tuff...... Phenocrysts: feldspar (11%), quartz (2%); groundmass (87%): clay-sericite, calcite, chlorite, leucoxene, iron ore, fluorite, apatite, zircon. Clay-sericite replaces much of groundmass feldspar; feldspar phenocrysts are embayed and wormy, showing poorly defined twinning and minor replacement by clay-sericite and chlorite; almond-shaped quartz appears to be reconstituted from chalcedonic amygdule filling; fluorite, apatite, and zircon associated with sphene-leucoxene after titaniferous iron ore. Grain size: to 2 mm. Texture: porphyritic, relict perlitic, amygdaloidal, and eutaxitic.

3420-3430'
Cuttings
Wt-2-7

Altered diabase...... Chlorite (32%), clay-zeolite (25%), plagioclase (20%), calcite (12%), iron ore (7%), sphene (3%), apatite (1%). Undetermined plagioclase highly altered to clay-zeolite with some calcite replacement; apatite as exceptionally large crystals; chlorite has completely replaced mafic minerals and is associated in part with sphene; magnetite as skeletal crystals. Grain size: to 1 mm. Texture: relict subophitic(?).

3700-3710'
Cuttings
Wt-2-8

Altered rhyolite porphyry...... Quartz, clay-sericite, feldspar, chlorite, calcite, iron ore, sphene-leucoxene, apatite. Pseudomorphs of clay-sericite after feldspar phenocrysts; groundmass appears devitrified with fuzzy and poorly crystallized minerals with finely disseminated chlorite throughout; vague suggestion of banding and relict spherulites; groundmass feldspar replaced in part by clay-sericite; minor quartz veins present. Grain size: relict phenocrysts to 1.2 mm. Texture: relict porphyritic and relict spherulitic.

3780-3790'
Cuttings
Wt-2-9

Altered rhyolite...... Quartz, clay-sericite, feldspar, chlorite, sphene-leucoxene, iron ore, apatite, zircon. A xenomorphic mosaic of quartz and clay-sericite with relatively minor feldspar; quartz appears to have been introduced in part; veins of calcite-hematite-quartz present; no original fabric remains, and the rock appears to be completely reconstituted. Grain size: to 0.15 mm. Texture: xenomorphic.

3850-3860'
Cuttings
Wt-2-10

Altered rhyolite...... Quartz, clay-sericite, feldspar, chlorite, pyrite, iron ore, zircon. A mosaic of quartz and clay-sericite with feldspar as relicts; no recognizable phenocrysts; chlorite as small shreds disseminated in irregular linear trends; pyrite as cubes; minor hematite staining; groundmass locally coarse. Grain size: to 0.2 mm. Texture: xenomorphic and relict spherulitic(?).

3950-3960'
Cuttings
Wt-2-11

Altered rhyolite porphyry...... Quartz, clay-sericite, feldspar, chlorite, calcite, iron ore, pyrite, leucoxene, zircon. Very similar to Wt-2-11, with the addition of relict phenocrysts replaced by clay-sericite; pyrite cubes common; iron ore as dusty particles with larger granules altered to leucoxene; calcite replaces irregularly. Grain size: relict phenocrysts to 1 mm. Texture: relict porphyritic and xenomorphic.

4020-4030'
Cuttings
Wt-2-12

Shell, 1 Galloway (cont.)

Altered rhyolite porphyry...... Quartz phenocrysts (7%), groundmass (93%): clay-sericite, feldspar, chlorite, pyrite, calcite, iron ore, zircon.

4200-4210'
Cuttings
Wt-2-13

Quartz phenocrysts with optically continuous groundmass quartz as rims, suggestive of relict spherulites; minor clay-sericite pseudomorphs after feldspar phenocrysts and as groundmass replacement; one chip is mylonitic; zircon grains are euhedral and relatively numerous. Grain size: phenocrysts to 0.5 mm. Texture: porphyritic and relict spherulitic(?).

Altered rhyolite porphyry...... Quartz, clay-sericite, feldspar, chlorite, calcite, iron ore, zircon.

4330-4340'
Cuttings
Wt-2-14

Xenomorphic granular mosaic of quartz and clay-sericite dominates groundmass, with finely divided but locally abundant chlorite; groundmass silicified; relict feldspar phenocrysts replaced by clay-sericite; hematite in irregular linear trends; calcite as irregular replacement. Grain size: relict phenocrysts to 0.7 mm. Texture: relict porphyritic and xenomorphic.

Mylonite....... Mylonitic paste, quartz, lithic relicts, calcite, chlorite, sphene-leucoxene, iron ore.

4510-4520'
Cuttings
Wt-2-15

Lithic relicts indicate that this is a rhyolite that has been mylonized; approximately 70 percent of the rock is mylonitic paste composed of quartz, clay, and possibly some relict feldspar; chlorite content high in irregular linear trends; iron ore and leucoxene as well-disseminated ragged grains. Grain size: variable. Texture: cataclastic.

Rhyolite tuff...... Quartz-clay-micas (72%), quartz (9%), leucoxene (8%), feldspar (5%), iron ore (3%), lithic fragments (2%), calcite (1%), zircon (tr.).

4550-4560'
Cuttings
Wt-2-16

A very fine-grained tuffaceous rock with an extremely fine-grained cement of clay-sericite-chlorite with some quartz; clastic fragments of quartz and feldspar are comparatively sparse and many fragments may have been destroyed when the clay-micas were formed; no apparent mica orientation; calcite as vein mineral; leucoxene with hematite stain in parallel but discontinuous bands. Grain size: to 0.2 mm. Texture: clastic.

Rhyolite tuff...... Chertose matrix, quartz, clay-sericite, feldspar, chlorite, lithic fragments, iron ore, fluorite, zircon.

4710-4720'
Cuttings
Wt-2-17

One chip shows mylontic lineation; chips differ greatly in mineral percentages, grain size, and texture; chertose cementing agent contains chlorite and probably clay-micas; hematite as only remaining iron ore; detrital fragments are mainly quartz and reconstituted lithic fragments. Grain size: to 0.7 mm. Texture: clastic.

Rhyolite tuff...... Matrix (55%), quartz (18%), feldspar (12%), lithic fragments (9%), pyrite (6%), chlorite (tr.), sphene (tr.), calcite (tr.), hematite (tr.), zircon (tr.).

4730-4740'
Cuttings
Wt-2-18

Quartz, feldspar, and lithic fragments are set in a matrix of very fine-grained material high in clay-sericite and quartz; granular sphene-leucoxene, irregular; pyrite as cubes; some detrital quartz grains have concave surfaces; some chlorite is in an amygdulelike filling; lithic fragments of diverse rhyolite. Grain size: to 0.9 mm. Texture: clastic.

Rhyolite tuff...... Lithic fragments (32%), matrix (21%), quartz (14%), chlorite (12%), feldspar (9%), sphene-leucoxene (4%), iron ore (2%), calcite (1%), pyrite (tr.), zircon (tr.).

5530-5550'
Cuttings
Wt-2-25

This description is typical of samples Wt-2-19 (4,830-4,840') through Wt-2-26 (5,690-5,700') and is generally characteristic of this rock unit, though some zones contain mylonitically lineated material; lithic fragments of diverse types of rhyolite, spherulites being particularly abundant; cementing matrix is extremely fine-grained chertose mosaic; margins of lithic fragments have been reconstituted; one large trachytic fragment noted. Grain size: to 1.5 mm. Texture: clastic.

Shell, 1 Galloway (cont.)

Rhyolite...... Feldspar, quartz, clay-sericite, calcite, chlorite, iron ore, sphene-leucoxene, iron ore, fluorite.

6000-6010'
Cuttings
Wt-2-27

Groundmass appears felted but relict spherulites are present; some minor clay-sericite replaces feldspar; sphene-leucoxene after titaniferous iron ore; hematite as tiny granules only remaining iron ore; calcite and minor fluorite as delicate vein; some vein quartz. Grain size: to 0.15 mm. Texture: felted and relict spherulitic.

Perlitic rhyolite porphyry...... Quartz, clay-sericite, feldspar, chlorite, iron ore, sphene-leucoxene, zircon, apatite.

6150-6160'
Cuttings
Wt-2-28

Delicate perlites with sericite and chlorite outlining cracks; most of the groundmass is a quartz-feldspar or quartz-sericite-clay intergrowth; amygdules filled with quartz reconstituted from chalcedony or feldspar, quartz, and chlorite; one chip contains much secondary silicification; some perlite cores replaced by sericite; chlorite irregular but appears controlled in part by perlite cracks; small relict feldspar phenocrysts replaced by clay-sericite. Grain size: to 0.3 mm. Texture: relict porphyritic, relict perlitic, and amygdaloidal.

Rhyolite porphyry...... Feldspar, quartz, clay-sericite, chlorite, calcite, sphene-leucoxene, iron ore, zircon, apatite.

6310-6320'
Cuttings
Wt-2-29

Phenocrysts of feldspar completely replaced by clay sericite; some replacement of feldspar in groundmass; sphene-leucoxene replacing iron ore, with associated apatite and zircon; hematite as dust in groundmass; calcite as irregular replacement. Grain size: relict phenocrysts to 1.5 mm. Texture: relict porphyritic and xenomorphic.

Perlitic rhyolite...... Feldspar, quartz, clay-sericite, chlorite, calcite, sphene-leucoxene, hematite, pyrite, zircon.

6500' cir.
Cuttings
Wt-2-30

Some perlites have monomineral cores with cracks outlined by hematite staining and chlorite; clay-sericite replaces irregularly in groundmass; pyrite as sparse cubes; minor vein quartz; chlorite appears controlled by perlites. Grain size: to 0.3 mm. Texture: perlitic.

All the basement rocks in this well are a part of the Carlton Rhyolite Group. The well is in a structurally complex area and is within 2 miles of the main fault bounding the north side of the central Wichita block. The universal introduction of clay and sericite replacing feldspar with attendant silicification, characterizes this area and is perhaps a deuteric or hydrothermal phenomenon. The exceptionally thick tuffaceous interval is probably complicated by steep dips and is probably not an accurate measure of true thickness of the group.

CHAMPLIN ET AL., 1 HIEBER   SW SW NW 30-8N-20W   (Wt-3)

Gabbro...... Plagioclase, calcite, zeolite-clay, tremolitic amphibole, iron ore, biotite, sericite, quartz, epidote, apatite, acicular inclusions.

2090-2120'
Cuttings
Wt-3-1

Pyroxene completely replaced by calcite-chlorite with minor hematite or by chlorite and tremolitic amphibole; biotite is red-brown and contains apatite crystals with weakly pleochroic halos; labradorite is veined with calcite and contains clay-zeolite alterations; sphene developed with chlorite; apatite as exceptionally large crystals. Grain size: to 5 mm. Texture: hypidiomorphic.

Champlin et al., 1 Heiber (cont.)

Banded quartz-bearing gabbro...... Plagioclase, feldspar alterations, biotite, chlorite, calcite, quartz, epidote, sericite, iron ore, sphene,
2540-2550' Cuttings Wt-3-2 apatite, acicular inclusions. Labradorite altered and cloudy, appears to have planar orientation; secondary quartz associated with minor sodic plagioclase; biotite is red brown and partly primary; epidote is intergranular; chlorite-biotite with minor associated calcite and sphene replace pyroxene; apatite exceptionally large. Grain size: 4 mm+. Texture: banded and hypidiomorphic.

Troctolite...... Plagioclase, iddingsite, olivine, biotite, iron ore, feldspar alterations, calcite, pyroxene, acicular inclusions. Labradorite
2910-2930' Cuttings Wt-3-3 containing opaque acicular inclusions is altered to clay-zeolites with some calcite; iddingsite as pseudomorphs after olivine; olivine has fine rim of pyroxene with radial intergrowth of pyroxene and reconstituted plagioclase around olivine or iddingsite grains; biotite is red brown and only mildly pleochroic; olivine crystals have iron-filled cracks. Grain size: to 7 mm+. Texture: hypidiomorphic and symplectic.

Gabbro...... Plagioclase, pyroxene, amphibole, biotite, chlorite, iron ore, feldspar alterations, apatite, acicular inclusions. Labradorite
3854' cir. Cuttings Wt-3-4 is fresh to clouded with alterations and contains opaque needles; pyroxene contains minor schiller iron ore and is associated with amphibole that is possibly primary; pyroxene altering to biotite, chlorite, and tremolitic amphibole; same symplectic intergrowth noted in previous interval is present, with the pyroxene somewhat altered and the core for the intergrowth being biotite, possibly as a pseudomorph. Grain size: 4 mm+. Texture: hypidiomorphic and symplectic.

Banded gabbro...... Plagioclase, pyroxene, biotite, iron ore, feldspar alterations, calcite, apatite, acicular inclusions. Length-oriented
4600-4630' Cuttings Wt-3-5 labradorite is delicately veined with zeolitic alterations and some secondary biotite; intergranular pyroxene is associated with alteration biotite and iron ore; calcite patches present in the more altered areas. Photomicrograph, pl. XIII-1. Grain size: 4 mm+. Texture: banded and hypidiomorphic.

Gabbro...... Plagioclase, pyroxene, feldspar alterations, biotite, iron ore, chlorite, calcite, acicular inclusions. Calcic labradorite contains
5280-5290' Cuttings Wt-3-6 veined alterations and opaque acicular inclusions; pyroxene with some schiller iron ore altering to biotite and chlorite with associated calcite; primary red-brown biotite occurs as well as secondary fibrous green biotite. Grain size: 4 mm+. Texture: hypidiomorphic.

Gabbro...... Plagioclase, pyroxene, amphibole, biotite, iron ore, chlorite, feldspar alterations, apatite, acicular inclusions. Pyroxene
6300-6320' Cuttings Wt-3-7 crystals associated with primary amphibole and primary biotite as rimming minerals; pyroxene alters to fibrous green biotite, tremolitic amphibole, and chlorite; iron ore in intimate but irregular association with mafic minerals; labradorite fresh to clouded with alterations. Grain size: greater than 4 mm. Texture: hypidiomorphic.

Olivine gabbro...... Plagioclase, pyroxene, biotite, amphibole, olivine, iron ore, calcite, chlorite, apatite, acicular inclusions. Fresh
6600-6620' Cuttings Wt-3-8 labradorite veined with shreds of biotite; pyroxene contains schiller and granule iron ore and is associated with basaltic hornblende; two varieties of biotite, one well crystallized and red brown, the other is olive green to reddish, in masses of unoriented shreds and occurs as alteration of mafic minerals, chiefly olivine; apatite is exceptionally large and is locally grouped with mafic minerals; masses of calcite

Champlin et al., 1 Heiber (cont.)
contain enclosed euhedral amphibole. Grain size: greater than 4 mm. Texture: hypidiomorphic.

Anorthosite...... Plagioclase, zeolitic alterations, calcite, sericite, acicular inclusions. Basically a labradorite rock with small veins of
7410-7430' Cuttings Wt-3-9 calcite cutting the plagioclase; an analcime-like zeolite is most common but other varieties are present; small amounts of sericite occur as alterations; acicular inclusions are well developed and at least part appear to be rutile. Grain size: 2.5 mm. Texture: hypidiomorphic to xenomorphic.

Olivine gabbro...... Plagioclase, pyroxene, olivine, amphibole, biotite, iron ore, chlorite, apatite, calcite, feldspar alterations, acicular
7850-7860' Cuttings Wt-3-10 inclusions. An exceptionally fresh rock; large olivine grains contain iron ore along cracks; pyroxene carries some schiller iron ore and is closely associated with basaltic hornblende; biotite is both a primary red-brown variety and a fibrous green alteration product; apatite crystals are exceptionally large and are in clustered groups; iron ore common in clots with olivine and pyroxene; one chip contains altered feldspar and pyroxene altering to tremolitic amphibole. Grain size: 3.5 mm and greater. Texture: hypidiomorphic to xenomorphic.

Olivine gabbro...... Plagioclase, olivine, amphibole, pyroxene, biotite, iron ore apatite, calcite, acicular inclusions. Fresh labradorite with small
8340-8350' Cuttings Wt-3-11 amounts of introduced material, mainly biotite and calcite, along cracks; calcite replaces a mafic mineral in a symplectic intergrowth with iron ore; olivine grains large and fresh, grouped with basaltic hornblende and pyroxene; biotite both primary and secondary; apatite crystals numerous and large, up to 0.7 mm in diameter. Grain size: 1.5 mm+. Texture: hypidiomorphic.

Gabbro...... Plagioclase, chlorite, biotite, iron ore, feldspar alterations, pyroxene, apatite, acicular inclusions. Intermediate labradorite
8770-8790' Cuttings Wt-2-12 containing cracks with alterations and introduced chlorite, with masses of alteration products commonly present at junctions of several cracks; small granules of pyroxene present in plagioclase; chlorite and fibrous green biotite are pseudomorphs after former intergranular mafic minerals; relict symplectic intergrowth present with iron ore and chlorite; some vein pyroxene(?) present. Grain size: 5 mm+. Texture: hypidiomorphic.

Troctolite...... Plagioclase, olivine, iron ore, biotite, tremolitic amphibole, iddingsite, chlorite, pyroxene, apatite, feldspar alterations,
9500-9520' Cuttings Wt-3-13 calcite, acicular inclusions. Large abundant fresh olivine grains with associated iron ore, locally replaced by chorite and tremolitic amphibole; occasional rims of basaltic hornblende around olivine; pyroxene small and generally discrete; intermediate labradorite contains minor alterations; some primary biotite present as well-crystallized books. Photomicrograph, pl. XIII-2. Grain size: to 2.5 mm. Texture: hypidiomorphic.

Granite...... Perthite (41%), quartz (30%), plagioclase (24%), chlorite (2%), biotite (1%), sphene (1%), epidote (1%), iron ore (tr.), calcite (tr.),
10015-10022' Core Wt-3-14 feldspar alterations (tr.), apatite (tr.), zircon (tr.). Feldspars are turbid with minor alterations and hematite dust; biotite altering to chlorite-sphene with epidote and iron ore in association; calcite as irregular blebs in feldspars and minor veinlets; the granite from this interval is particularly diverse in texture, grading from micrographic to hypidiomorphic in a single thin section. Grain size: to 2.5 mm. Texture: hypidiomorphic to micrographic.

Champlin et al., 1 Heiber (cont.)

The basement rocks are in the Raggedy Mountain Gabbro Group, and this well probably represents the maximum penetration of gabbroic rocks in the world.

The well is located in an extremely complex area of faulting near the north boundary of the Wichita Mountain platform, and the indicated thickness of basement rocks, approximately 8,000 feet, must be considered unreliable because the dips are probably steep and there may be some repetition due to faulting.

Shows of oil and gas were obtained 5,500 feet below the top of the basement, at a depth of 7,760 feet. The oil and gas undoubtedly migrated into the gabbro across a nearby fault from Paleozoic sedimentary rocks at a comparable depth a short distance to the north.

A core taken at 10,015-10,022 feet shows the bottom rock to be anorthosite that is cut by a typical granite of the Wichita Granite Group.

Samples from this well, particularly from the upper part, are of poor quality. The rock is noteworthy for its high content of biotite, which occurs with the cutting chips as numerous loose books.

SUNRAY & AUBYME, 1 MARY RICE SE SE SE 33-8N-18W (Wt-4)

Granite porphyry......	Perthite (42%), quartz (24%), plagioclase (21%), chlorite (5%), calcite (3%), feldspar alterations (2%), iron ore (1%),
2024-2029'	biotite (1%), sphene (1%), epidote (tr.), apatite (tr.), zircon (tr.).
Cuttings	Large phenocrysts of feldspar in a finer groundmass of quartz and
Wt 4-1	feldspar; feldspars clouded with hematite dust and alterations; chlorite-calcite replace former mafic mineral, probably horn-

blende; biotite is secondary and vermicular; epidote as granules in feldspars; calcite as veins and irregular blebs. Grain size: to 2 mm. Texture: porphyritic.

The well penetrated rock of the Wichita Granite Group.

INDEX

(*Italic number* indicates main reference)

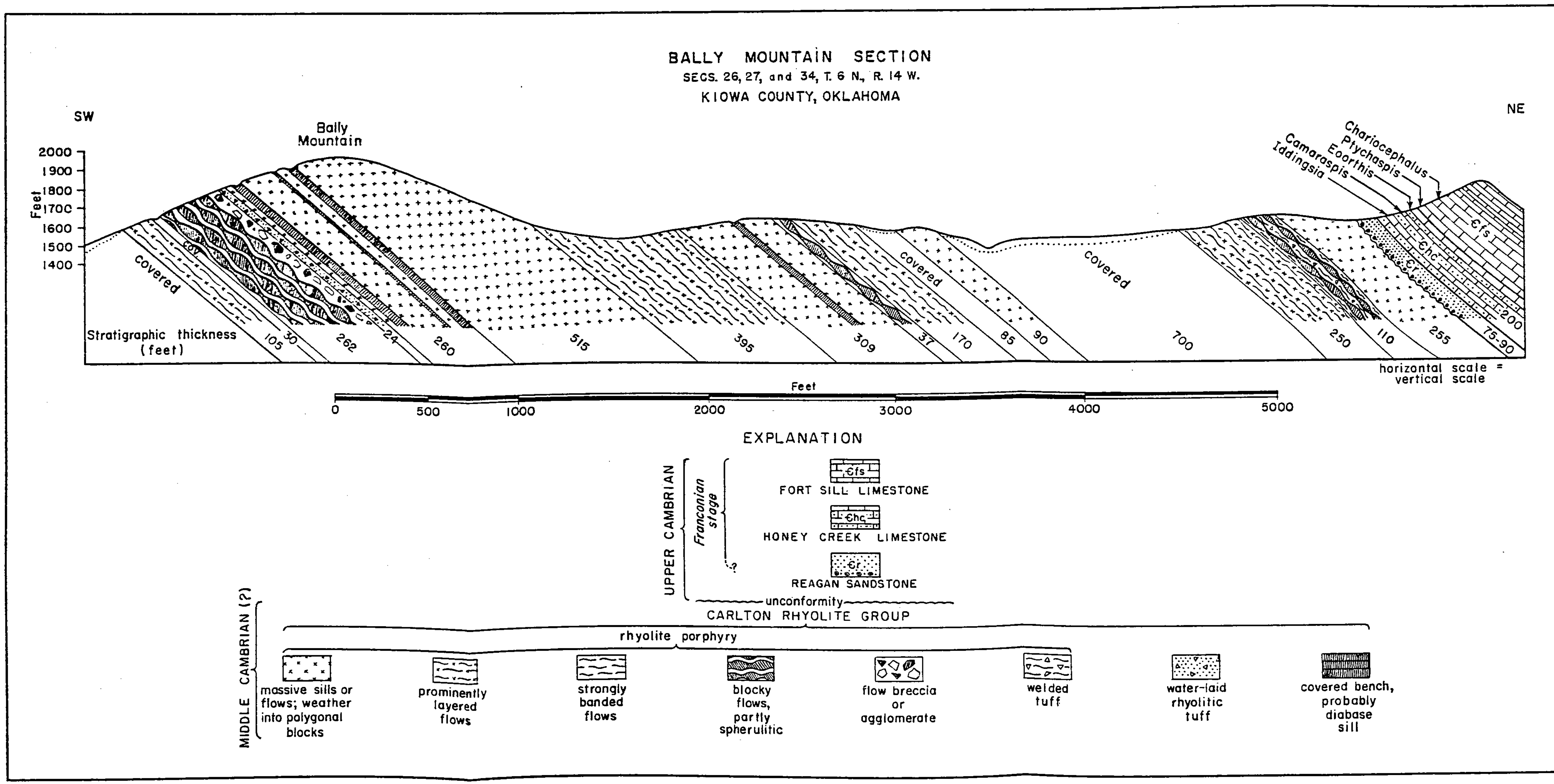

Figure 4. Stratigraphic section of Carlton Rhyolite at Bally Mountain.