FIELD TRIP GUIDEBOOK

THE STRUCTURE AND IGNEOUS ROCKS OF THE WICHITA MOUNTAINS, OKLAHOMA

First Annual Meeting

THE SOUTH-CENTRAL SECTION
of
The Geological Society of America, Inc.

April 1, 1967

F I E L D   T R I P   G U I D E B O O K

THE STRUCTURE AND IGNEOUS ROCKS
OF THE WICHITA MOUNTAINS, OKLAHOMA

Edited by

George T. Stone
The University of Oklahoma

FIELD TRIP CONTRIBUTORS AND LEADERS

William E. Ham
Oklahoma Geological Survey

Hugh E. Hunter
State University of New York at Binghamton

Clifford A. Merritt
The University of Oklahoma

George T. Stone
The University of Oklahoma

First Annual Meeting

THE SOUTH-CENTRAL SECTION

of

The Geological Society of America, Inc.

April 1, 1967

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

It is somewhat surprising that the nature of an area of as much geologic interest as the Wichita Mountains is not familiar to most geologists. The significant structural relationships and distinctive assemblages of igneous rocks that characterize the province deserve more attention. This field trip attempts to acquaint the participants with some of the salient geologic features of the Wichita Mountains. Necessarily, many interesting aspects of the local geology are largely or entirely ignored.

It is very fortunate that those most familiar at first hand with the principal geologic features of the Wichita Mountains, William E. Ham, Hugh E. Hunter, and Clifford A. Merritt, are the field trip contributors and leaders. Sincere appreciation is due them for agreeing to participate on relatively short notice.

This field trip and guidebook result from the efforts of many in addition to the contributors and leaders,and, although space does not permit acknowledgment of all, I wish to personally thank the following: Charles J. Mankin, Vice-Chairman of the South-Central Section, who has given full support at all stages of preparation; Mrs. Pat Brown who typed most of the rough and final copy for the guidebook; Alex.Nicholson who proof read the copy and a arranged for printing the guidebook; Roy Davis who did some last minute drafting; and Anne Marie Stone who helped in compiling the route log and in making arrangements for the trip. Responsibility for errors which may appear in the guidebook is mine.

The first annual meeting of the South-Central Section of the Geological Society of America, Inc., including the field trip, is under the auspices of the School of Geology and Geophysics and the Oil Information Center, both of the University of Oklahoma, and the Oklahoma Geological Survey.

George T. Stone

BASEMENT ROCKS AND STRUCTURAL EVOLUTION OF SOUTHERN OKLAHOMA: A SUMMARY

by

William E. Ham

Introduction

The Wichita Mountains of southwestern Oklahoma comprise an area of igneous rock hills, chiefly gabbroic rocks, granites, and rhyolites, that is being exhumed from a cover of Permian red shales. They are the principal outcrop of the basement complex in the Midcontinent region. Long considered to be typical of the Precambrian basement of the craton, the rocks of the Wichita Mountains have been shown in recent studies to be of Middle to Late Cambrian age, constituting the youngest major body of igneous rocks of the North American craton. The rhyolites, although scarce at the surface, are widely distributed in the subsurface of southern Oklahoma; they are not structurally part of the cratonic basement but are part of a thick stratified sequence deposited during the early stages of formation of the Anadarko basin, the deepest and geologically the most persistent basin of the craton. For structural and petrologic reasons, the rocks of the Wichita province are unique in the geological development of North America.

Newly developed concepts concerning the basement rocks and structural evolution of southern Oklahoma were published in Oklahoma Geological Survey Bulletin 95 (Ham, Denison, and Merritt, 1964). The region of southern Oklahoma studied comprises about 17,000 square miles, including outcrops of the Wichita Mountains and Arbuckle Mountains, together with a much greater area in subsurface between and around these uplifts (Pl. I, Okla. Geol. Survey Bull. 95). Information from Bulletin 95 has been used extensively in this guidebook to provide a regional framework for field study of the granitic, rhyolitic, and gabbroic rocks in the Wichita Mountains.

Geologic Setting

The region of interest in southern Oklahoma is about 225 miles long and 65 miles wide. It comprises all of south-central and southwestern Oklahoma between the Ouachita Mountains and the Texas Panhandle, including the strongly folded Palezoic rocks of the Arbuckle Mountains in the east and the prominent hills of granite and gabbro exposed in the core of the Wichita Mountains in the west (Fig. 1). Surrounding the Arbuckle and Wichita Mountains is a cover of Pennsylvanian and Permian sedimentary rocks of generally low dip, and south of the Arbuckle Mountains lie the gently southward-dipping Cretaceous sediments of the Gulf Coastal Plain. Basement-rock outcrops comprise about 400 square miles in the Wichita Mountains and about 150 square miles in the Arbuckle Mountains. In much of the region, basement rocks are penetrated by wells at depths less than 5,000 feet. However, the structural relief is so great that the basement rocks probably lie at depths of 30,000 to 40,000 feet in the deepest basins of the region.

Through a combination of surface and subsurface geologic study, 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 most significant recent contributions have resulted from subsurface investigations, and from radiometric age determinations of flows and intrusive rocks in outcrop and in subsurface. More than 400 wells have been drilled into basement rocks in 17 counties; this wide coverage has permitted mapping of rock units in the subsurface (which reveals a distribution strikingly

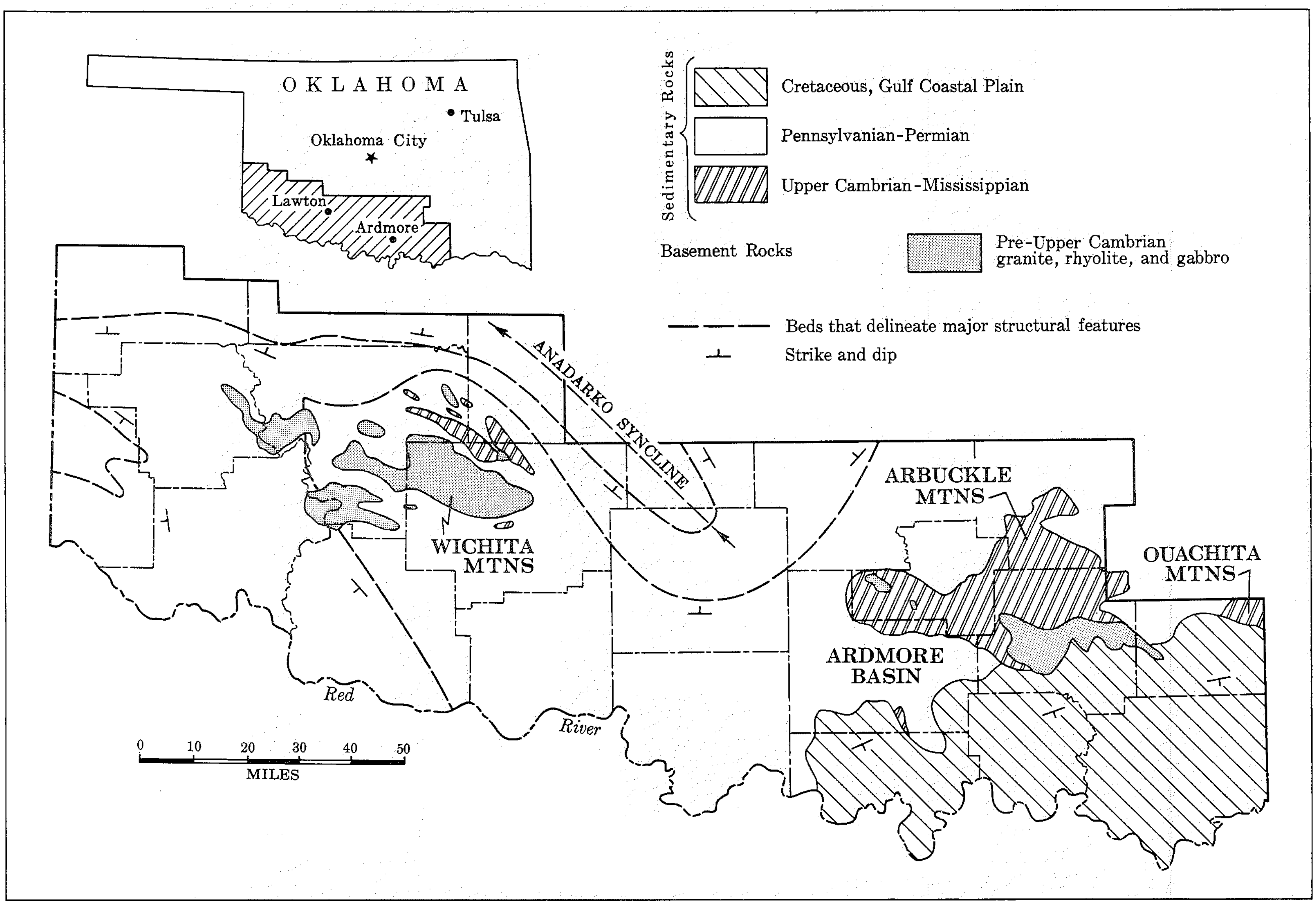

Figure 1. Index map of southern Oklahoma, showing major outcrops and structural features.

different than that which had been expected on the basis of surface studies) and discovery of two important rock groups that do not crop out in the Wichita or Arbuckle Mountains. Exceptionally deep penetration of basement rocks (more than 4,000 feet in 6 wells and more than 1,000 feet in 17 wells) has provided data on the thicknesses and geometry of volcanic rocks, and has allowed interpretation of intrusive relations and lithologic changes. Of great importance to basement-rock geology are the high-angle reverse faults penetrated by many wells in the Arbuckle-Wichita region. In some wells, as the Honeymon no. 1 Towsend in Bryan County and the Frankfort no. 1 Freeman Heirs in Murray County, thick basement rocks were penetrated before cutting through a reverse fault into Ordovician sedimentary rocks below.

These investigations have led to recognition and mapping of six basement rock groups which occur in two geologic provinces (Tables 1 and 2). Five groups are related to the Wichita Mountains and are herein termed the rocks of 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 known to be much more widespread in the subsurface. Two additional groups (Navajoe Mountain Basalt-Spilite Group and Tillman Metasedimentary Group) are also widespread in the subsurface but do not crop out in the region.

Previously assigned to the Precambrian, the rocks of the Wichita province range in radiometric age from 500 to 550 million years and are now believed to be mostly or entirely of Middle and Late 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 basement that

TABLE 1. Basement - Rock Groups and Provinces in Southern Oklahoma

TIME	ROCKS	
LATE CAMBRIAN	Reagan Sandstone, Honey Creek Limestone, and lower part of Arbuckle Group	
	- - - UNCONFORMITY - - -	
	EXTRUSIVE AND METASEDIMENTARY	INTRUSIVE
	Carlton Rhyolite Group	Wichita Granite Group
LATE CAMBRIAN	Flows and pyroclastics; at least 4,500 feet; extrusive equivalent of Wichita granites; 4 age dates (525 ± 25 m.y.)	Perthitic leucogranites; sills (cutting lower Carlton rhyolites) and irregular plutons; 4 age dates (525 ± 25 m.y.)
	- - - PROBABLE UNCONFORMITY - - -	
MIDDLE CAMBRIAN (?)	Navajoe Mountain Basalt-Spilite Group Basalt, spilite, andesite and palagonite tuff in subsurface; several thousand feet likely; underlies Carlton rhyolites; intruded by Wichita granites; probable extrusive equivalent of Raggedy Mountain Gabbro Group.	Raggedy Mountain Gabbro Group Gabbros, anorthosite, and troctolite of layered instrusion; possibly 10,000 feet; injected as elongate lens into Tillman sediments; cut by Wichita granites; 2 age dates (535 ± 30 m.y.)
LATE PRECAMBRIAN OR EARLY CAMBRIAN	Tillman Metasedimentary Group Low-grade meta-graywacke, argillite, quartzite, and bedded chert in subsurface; probably at least 15,000 feet.	
	- - - MAJOR UNCONFORMITY - - -	
PRECAMBRIAN		Eastern Arbuckle Province Coarse biotite-plagioclase-microcline granites of 2 ages (1,050 m.y. and 1,350 m.y.); subsurface horneblende diorite sills (1,200 m.y.) in older granite.

TABLE 2. 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.); most feldspar is perthite; plagioclase less than 5%. Little or no microcline.	Two feldspar granites (1,050-1,350 m.y.); microcline ubiquitous with plagioclase.
Micrographic quartz-perthite intergrowths common.	Micrographic quartz-feldspar intergrowths rare.
Riebeckite-aegirite locally in small amount.	Riebeckite-aegirite unknown.
Straining of large quartz grains inconspicuous to moderate.	Straining of large quartz grains moderate to pronounced.
Gneissic structure absent. Granites locally cataclastic.	Local slight gneissic structure, cataclastic features, incipient metamorphism.
Epizonal.	Mesozonal.
GABBROIC ROCKS	
Gabbros, troctolite, anorthosite.	Gabbroic rocks unknown.
Diorite (535 m.y.) contains pyroxene and reddish-brown biotite; with related rocks of large gabbro intrusion.	Diorite (1,200 m.y.) contains hornblende and olive-green biotite; in granite as dikes and sills; locally schistose.
VOLCANIC ROCKS	
Carlton Rhyolite Group; flows and pyroclastics (525 m.y.).	Rare dikes of rhyolite porphyry which resembles Carlton rhyolite.
Navajoe Mountain Basalt-Spilite Group (flows and tuffs).	Rock type unknown.
METAMORPHIC ROCKS	
Tillman Metasedimentary Group; biotitic graywackes.	Rock type unknown.
Hornfels and biotite schists locally at granite contacts.	Hornblende-biotite schist inclusions in granite.

characterizes large segments of the Central United States.

Wichita Province

The youngest rocks of the Wichita province are rhyolites and granites dated at 525 $\pm$ 25 million years. Consisting mainly of subaerially extruded rhyolite flows and pyroclastics, the Carlton Group represents an extensive volcanic field and is least 4,500 feet thick. Rocks of the Wichita Granite Group are chiefly perthite leucogranites which were emplaced as multiple epizone intrusions, in part as sills 600 to 1500 feet thick in the lower part of the Carlton rhyolite, and in part as irregular plutons and sills cutting all other rocks of the Wichita province. Wichita granite is the intrusive equivalent of the extrusive Carlton rhyolite; they are virtually identical chemically, each having an average silica content of about 75 per cent.

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 origin) in a subsurface sequence having a drilled thickness of 1,050 feet and a probable total thickness of several thousand feet. These rocks underlie Carlton rhyolite and are intruded by Wichita granite, locally metamorphosed to hornfels of relatively high grade. The Navajoe Mountain Group is regarded as the extrusive equivalent of the Raggedy Mountain Gabbro Group, which is radiometrically dated at about 535 million years. The main part of the Raggedy Mountain Group consists of gabbro, olivine gabbro, troctolite, and anorthosite in the form of a layered intrusive, possibly as much as 10,000 feet thick, which was 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, which represents marine eugeosynclinal deposits of probable Early Cambrian age. Graywacke is converted into hornfels and biotite schist near intrusive contacts with Wichita granite, and quartizite 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 hornblende diorite (1,200 million years) which occurs in the subsurface as sills in the older granite. Granites of this province are petrographically and chemically distinct from the Wichita granites (Table 2). Eastern Arbuckle granites generally contain at least 20 per cent oligoclase and they are notably lower in silica (73%), and higher in alumina (14%) and lime (1.5%) than the perthite-rich Wichita granites. Eastern Arbuckle granites characteristically show incipient growth of crystalloblastic muscovite, biotite, and hornblende, whereas such growth generally is lacking in the younger granites of the Wichita province.

Role of Basement Rocks in Structural Evolution

The basement rocks have had a profound influence on the stratigraphic and structural evolution of southern Oklahoma. During Precambrian time, an extensive continental mass was injected by granites, forming a relatively rigid cratonic block. The eastern part of this block has been a stable element from the time of its formation to the present. Following long uplift and deep erosion, it received a relatively thin cover of Paleozoic sedimentary rocks which have been deformed by gentle folding and block faulting; the Tishominog-Belton-Hunton uplift of the Arbuckle Mountains region is an example. A somewhat similar block is represented in the subsurface by the Muenster arch. A great intracratonic sag developed in the granitic basement in all other parts of southern Oklahoma, initiating the Southern Oklahoma geosyncline which was destined to receive as much as 60,000 feet of Paleozoic rocks (Fig. 2). The accumulation may be divided into three stages, of which the earliest, although previously unrecognized, constitutes one-third of the total thickness and was of paramount importance in setting a pattern for subsequent development.

The earliest stage was eugeosynclinal and is represented by as much as 20,000 feet of graywacke, bedded chert, spilitic basalt, and rhyolite of the Wichita province of Middle and Late Cambrian age. At this stage the geosyncline was about 100 miles wide and, in Oklahoma, nearly 300 miles long. It doubtless extended much farther southeastward through the present Ouachita fold belt and, perhaps, connected with the Appalachian geosyncline.

A part of the geosynclinal 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 irregular plutons. These intrusive rocks apparently had the effect of making a large portion of the margin more resistant to deformation so that it no longer participated in the geosynclinal sinking, but later became the site of the block-faulted Wichita Mountains uplift. As a result, the locus of later geosynclinal deposition was shifted slightly to the north.

Before the first stage of the Southern Oklahoma geosyncline ended with widespread extrusion of Carlton rhyolite, major faults originated along

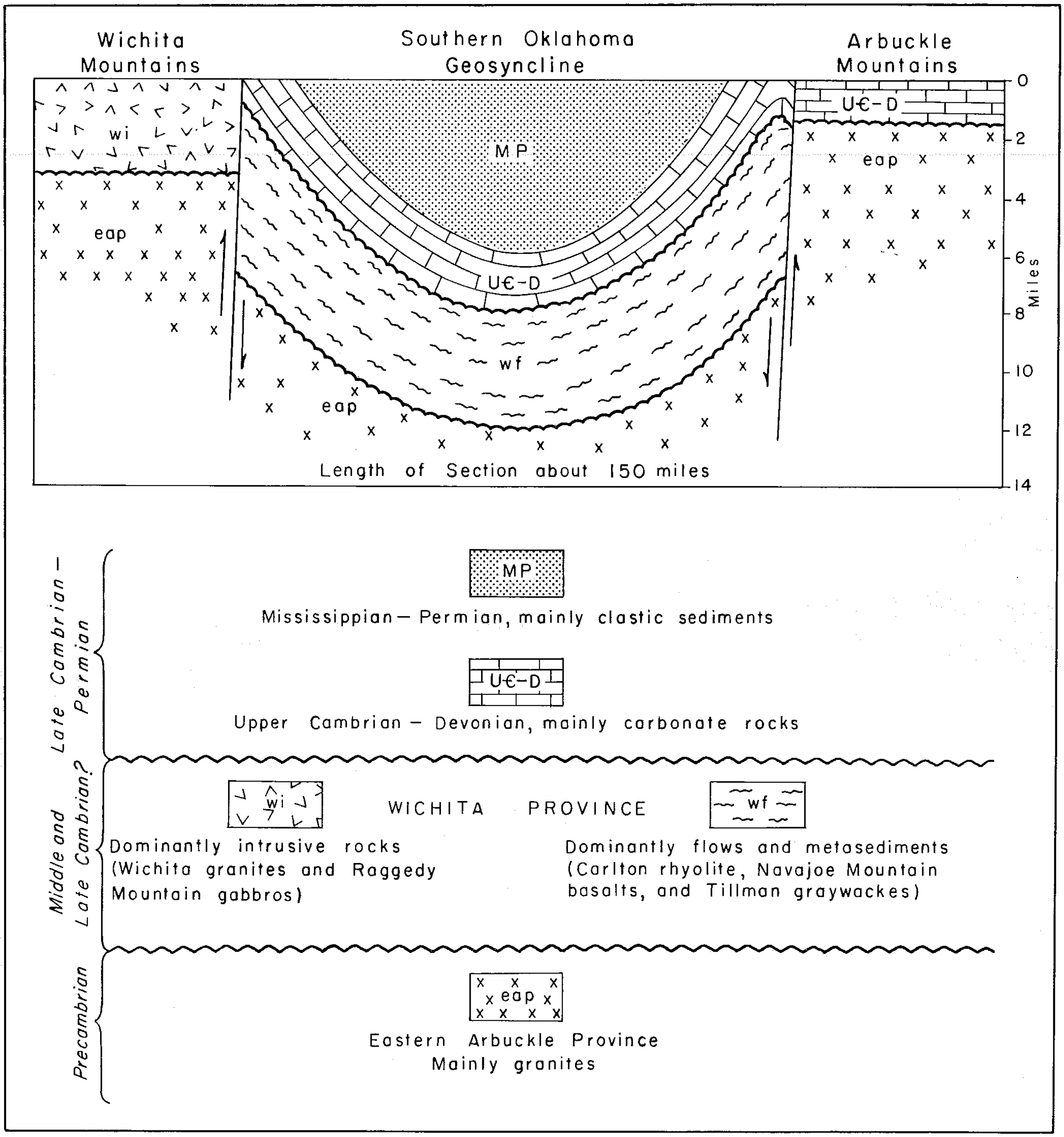

Figure 2. Schematic diagram of the Southern Oklahoma geosyncline.

opposite margins of the newly modified basin. The basin itself dropped 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 northwest-trending faults which evince enormous movement during Pennsylvanian time. The implication is clear that the structural grain of Late Paleozoic orogeny in southern Oklahoma was established during the Middle Cambrian 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 structural units have many features in common (Fig. 2): their basement rocks are stratiform volcanics 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 in thickness from 30,000 to 40,000 feet. They represent the two later stages of filling of the Southern Oklahoma geosyncline: a miogeosynclinal stage of Upper Cambrian to Devonian carbonate rocks, and a final zeugogeosynclinal stage of clastic sedimentation during Carboniferous and Permian time.

In addition to establishing a pattern of downwarp for the sinking basin, the basement rocks of the Wichita province influenced the magnitude and intensity of folding that occurred during the several stages of Pennsylv orogeny. The stratiform volcanics are thick and structurally conformable with the overlying sediments; thus, they acted as a foldable platform instea of an unyielding, rigid base, and allowed the formation of closely folded anticlines and synclines. Such folding is restricted in southern Oklahoma to those areas that are underlain by stratiform rocks of the Wichita province.

The dominant feature in the development of the Southern Oklahoma geosyncline was the persistence of basinward downwarp throughout a long span of geologic time during which the geosyncline passed through three distinctive stages without significant pause in sedimentation. It is probable that the geosyncline is wholly of Paleozoic age because the youngest sediments are Permian and the oldest deposits (Tillman graywacke) are considered Early Cambrian. The development of this geosyncline was profoundly influenced by the character and thickness of its basement rocks. In its history of sinking and filling by thick deposits followed by strong folding and thrust faulting, the geosynclinal belt is markedly different in all its evolutionary aspects from the region underlain by massive intrusions.

ROUTE LOG AND MAP

A generalized geologic map of the Wichita Mountains showing the route of the field trip follows this log (Fig. 3).

CUMULATIVE MILEAGE	MILEAGE FROM PRECEDING LOCATION	LOCATIONS AND DIRECTIONS
0.0		(1) The University of Oklahoma. Proceed West on Lindsay Street.
2.2	2.2	(2) Turn right to Interstate 35 South.
3.2	1.0	(3) South Canadian River
4.2	1.0	(4) Turn right on State Highway 9 West.
10.0	5.8	(5) Turn right on U.S. 62-277 North.
16.9	6.9	(6) Turn left to enter H. E. Bailey Turnpike Southwest.
79.5	62.6	(7) Turn right to State Highway 49 West. (Prominent granite hills of Wichita Mountains to West and Southwest.)
85.2	5.7	(8) Nonconformity in roadcut on right. Lower Permian Post Oak conglomerate lies on Carlton rhyolite intruded by Wichita granite.
86.4	1.2	(9) Enter Wichita Mountains Wildlife Refuge.
88.2	1.8	(10) Turn right on road to summit of Mt. Scott.
91.1	2.9	(11) STOP 1: TOP OF MT. SCOTT
94.0	2.9	(12) Return to location 10 and turn left on State Highway 49 East.
98.9	4.9	(13) Turn left on State Highway 58 North. (Carbonate rocks of Arbuckle and Timbered Hills Groups, Reagan Sandstone, and Carlton rhyolites are exposed along highway as it crosses Blue Creek Canyon anticline.)
112.5	13.6	(14) Turn left on State Highways 19-58 West.
115.5	3.0	(15) Turn right and continue on State Highway 58 North.

CUMULATIVE MILEAGE	MILEAGE FROM PRECEDING LOCATION	LOCATIONS AND DIRECTIONS
129.5	14.0	(16) Carnegie, Oklahoma; turn left on State Highway 9 West.
136.9	7.4	(17) Turn left on State Highway 115 South. (Reduction of redbeds below gypsum of Permian Blaine Formation conspicuous in road cut on right.)
147.5	10.6	(18) Turn left and continue on State Highway 115 East.
148.5	1.0	(19) Proceed on section line road East.
150.5	2.0	(20) Turn right on section line road South at foot of Bally Mountain.
151.5	1.0	(21) Turn left on section line road East.
152.5	1.0	(22) Turn left on section line road North.
154.0	1.5	(23) STOP 2: TOP OF CARLTON RHYOLITE AND BASE OF REAGAN SANDSTONE.
157.5	3.5	(24) Return to location 20. STOP 3: CARLTON RHYOLITE AT BALLY MOUNTAIN.
171.1	13.6	(25) Return to location 17 and turn left on State Highway 9 West.
172.3	1.2	(26) Mountain View, Oklahoma.
179.6	7.3	(27) Gotebo, Oklahoma; turn left on State Highway 54 South.
193.9	14.3	(28) Cooperton, Oklahoma; proceed South on State Highway 54. (Raggedy Mountains visible to Southwest.)
198.8	4.9	(29) Turn left on section line road East.
200.8	2.0	(30) Turn right on section line road South.
201.8	1.0	(31) Turn left on section line road East.
202.8	1.0	(32) Turn right on section line road South.
205.8	3.0	(33) Turn left on State Highway 49 East.
208.0	2.2	(34) Enter Wichita Mountains Wildlife Refuge.
208.4	0.4	(35) STOP 4: IRA SMITH GRANITE QUARRY (LUNCH STOP).

CUMULATIVE MILEAGE	MILEAGE FROM PRECEDING LOCATION	LOCATIONS AND DIRECTIONS
218.0	9.6	(36) Return to location 29 and turn right on State Highway 54 North.
222.3	4.3	(37) Proceed West on State Highway 19.
225.0	2.7	(38) Turn left on section line road South.
229.0	4.0	(39) STOP 5: DIKE OF BIOTITE OLIVINE GABBRO. Proceed on section line road West.
230.9	1.9	(40) Turn left on section line road South.
231.9	1.0	(41) Turn right on section line road West.
233.5	1.6	(42) Turn right on U.S. 183 North.
235.5	2.0	(43) STOP 6: INTRUSION BRECCIA. AND STOP 7: RHYTHMIC LAYERING OF TROCTOLITE AND ANORTHOSITE. Turn around and proceed on U.S. 183 South.
244.1	8.6	(44) Mountain Park, Oklahoma.
247.2	3.1	(45) Snyder, Oklahoma; turn left on U.S. 62 East.
259.2	12.0	(46) Indiahoma, Oklahoma.
266.9	7.7	(47) Cache, Oklahoma.
279.1	12.2	(48) Lawton, Oklahoma (POSSIBLE DINNER STOP).
281.7	2.6	(49) Join U.S. 277-281 North and return to Norman via H. E. Bailey Turnpike.
367.0	85.3	(50) The University of Oklahoma.

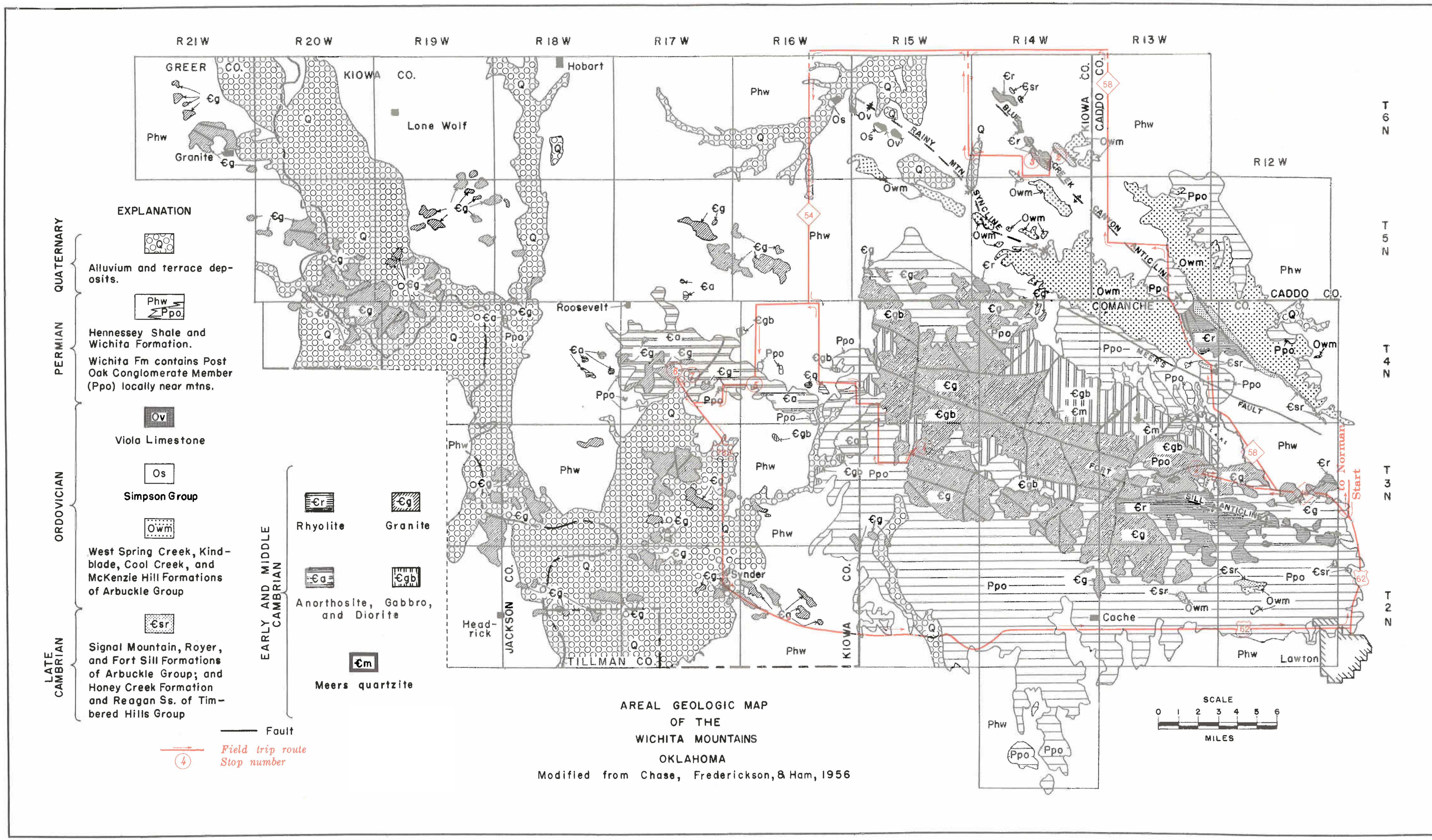

Figure 3. Geologic map of the Wichita Mountains, showing route of field trip.

STOP 1: TOP OF MT. SCOTT, SE¼ sec. 11, T. 3 N., R. 13 W., Comanche County (W. E. Ham, C. A. Merritt, and G. T. Stone).

Mount Scott, which dominates the scenery of the eastern Wichita Mountains, rises 1,118 feet above Lake Lawtonka and is the highest point in southern Oklahoma. It is composed largely of Mt. Scott Granite which crops out in much of the surrounding area. Many essential geologic features of the Wichita Mountains can be seen in panoramic view from the top of Mt. Scott (Fig. 3).

To the south is Lake Elmer Thomas and to the east Lake Lawtonka (elevation 1,346 feet); both lakes are manmade, and Lake Lawtonka furnishes water for the city of Lawton. The small village south of Lake Lawtonka is Medicine Park, and beyond is the Fort Sill Military Reservation. The major rock type underlying the Reservation is Carlton rhyolite, which forms smooth, rounded hills. This unit is composed of interbedded rhyolite flows and pyroclastics, including welded tuffs. Its 35-square-mile exposure is the largest single outcrop of volcanic rocks in Oklahoma. Carlton rhyolite is locally at least 4,500 feet thick and extends in the subsurface from the eastern part of the Arbuckle Mountains to the Texas Panhandle. Directly south, on the opposite shore of Lake Elmer Thomas, the lower part of the rhyolite has been converted into hornfels by intrusion of Mt. Scott Granite.

To the southwest may be seen more rugged hills which are composed of Quanah granite, a coarse-grained rock believed to have been emplaced as a shallow (epizone) pluton. To the west, Mt. Sheridan is capped by a sill of Mt. Scott Granite which overlies gabbro and diorite of the Raggedy Mountain Gabbro Group exposed on its lower tree-covered slopes (Fig. 4).

Northward from Mt. Scott are the Limestone Hills, composed of carbonate rocks of the Arbuckle Group. They are separated from the Wichita Mountains

Figure 4. View from the top of Mt. Scott looking westward toward Mt. Sheridan (left-center). Granite dated at 525 million years composes most of the hills that can be seen. Gabbro and diorite underlie the sill of granite that caps Mt. Sheridan.

by the Meers fault, which, along with other faults, extends for some 200 miles across southern Oklahoma and exhibits vertical displacement of up to 30,000 feet. Eight miles northeast of Mount Scott, on the opposite side of the Meers fault, is one of the most important basement-rock wells in Oklahoma, the Stanolind no. 1 Perdasofpy (SE¼ NW¼ SW¼ sec. 11, T.4N., R.12W.). In this well, the rock succession beneath Reagan sandstone is: Carlton rhyolite, 2,590 feet; micrographic Wichita granite, 615 feet; and basaltic rocks of the Navajoe Mountain Group, 1,049 feet. The granite exhibits chilled upper and lower contacts and is apparently a sill. The underlying rocks are not gabbro, as at Mt. Sheridan and Mt. Scott, but spilite, basalt, and tuff of the Navajoe Mountain Group.

Presumably the Navajoe Mountain volcanics were originally present above the gabbro in the Mt. Scott area, but were eroded away during a period of pre-rhyolite uplift. Rhyolitic volcanics probably were erupted upon an eroded surface of gabbro, and the granite of Mt. Scott was later injected along the contact. Uplift sufficient to allow erosion of a thick sequence of basaltic rocks was probably accomplished in part by faulting along a zone nearly parallel to or coincident with the Meers fault. Having been active in pre-rhyolite time with upthrown on the south and a displacement probably exceeding 1 mile, the fault was rejuvenated during a stage of Pennsylvanian orogeny and now shows a throw of about 4 miles. Thus, in the Wichita Mountains, as in the Arbuckle Mountains, older faults that originated in the basement rocks influenced the younger structural patterns of Late Paleozoic time.

The known basement rocks of the Wichita province probably are of Middle and Late Cambrian age. Wichita granite and Carlton rhyolite are the youngest, having radiometric ages of about 525 million years. Raggedy Mountain gabbro with a radiometric age of 535 million years is next oldest, and is considered to be the intrusive equivalent of the Navajoe Mountain Basalt-Spilite Group. The oldest rocks are those of the Tillman Metasedimentary Group; they do not crop out in the Wichita Mountains but are widely distributed in the subsurface.

MT. SCOTT GRANITE

by

Clifford A. Merritt

The granite which forms approximately half of the outcrop area in the eastern and central Wichita Mountains was named Mt. Scott Granite by Merritt (1965) after Mt. Scott, which is composed of this rock. It formerly had been mapped as Lugert Granite. The rock is a leucogranite with a low ferromagnesium content, generally less than 5 per cent; microperthite is the dominant constituent and free plagioclase is minor or absent. On fresh surfaces the rock is salmon pink and speckled with small dark spots of ferromagnesian minerals; it weathers to deep brick red.

Mt. Scott Granite is medium-grained and slightly porphyritic. The largest phenocrysts are microperthite 2 to 4 mm in length and rounded to elliptical in cross section. Many of the phenocrysts have an outer rim of micropegmatite that gives them a two-tone color with a central core of gray or brown and an outer rim of pink or red. The rock typically is granophyric, but the micropegmatite content varies markedly, being greater at the intrusive contacts. The average mode of four thin sections of Mt. Scott Granite is: micropegmatite, 59.4%; microperthite and orthoclase, 27.0%; quartz, 9.2%; hornblende, 2.4%; titaniferous magnetite, 1.6%; sphene, 0.4%; and traces of apatite, biotite, garnet, allanite, chlorite, and augite. The augite is a relict mineral of a small assimilated gabbro inclusion.

Inclusions of country rock are common in Mt. Scott Granite. The xenoliths are variable in amount but locally exceed 2 per cent by volume. They are generally small (less than 2.5 cm in maximum diameter), and many are microscopic. Gabbro and anorthosite are the principal country rocks intruded by the granite and most of the inclusions are altered fragments of those rock types. A few xenoliths of Meers Quartzite and Carlton Rhyolite have also been found.

Mt. Scott Granite apparently was emplaced as an intrusive sheet which must have had an areal extent of hundreds of square miles. Outcrops of this rock are found within an area of almost 900 square miles, and it is also present in the subsurface on the flanks of the Wichita Mountains. The measured thickness of the granite on Mt. Scott is 980 feet, but the dip of the sill is unknown, and the true thickness may be considerably less. The dip of the sill exposed on Mt. Sheridan is approximately 5 degrees to the south, but there is a large fault between this exposure and Mt. Scott. In the Stanolind no. 1 Perdasofpy well a few miles to the north, a granite sill about 500 feet thick and similar to Mt. Scott Granite was encountered at a depth of 8,000 feet. The Mt. Scott intrusive sheet probably has a thickness of about 500 feet.

Mt. Scott Granite is believed to have been emplaced at shallow depths (epizone) because it intrudes the older rocks of the Carlton Rhyolite Group. Xenoliths of Carlton Rhyolite are found in Mt. Scott Granite and dikes of rhyolite cut the granite. Therefore, Mt. Scott Granite is younger than the early rhyolites and older than the late rhyolites of the Carlton Rhyolite Group, which is the extrusive equivalent of the Wichita Granite Group.

Mt. Scott Granite is the oldest member of the Wichita Granite Group. The granite members of this group are very similar chemically and mineralogically and are believed to be comagmatic. Radiometric determinations have given the age of the granites and rhyolites of the Wichita Mountains as approximately 525 million years, indicating Middle to Late Cambrian age.

STOP 2: TOP OF CARLTON RHYOLITE AND BASE OF REAGAN SANDSTONE, N½ NW¼ sec. 26, T. 6 N., R. 14 W. (W. E. Ham).

STOP 3: CARLTON RHYOLITE AT BALLY MOUNTAIN, SW¼ SW¼ SW¼ sec. 27, T. 6 N., R. 14 W., (W. E. Ham).

Stops 2 and 3 are at separate parts of the Bally Mountain measured section (Fig. 5), the type locality of the Carlton Rhyolite Group. The top of Bally Mountain rises to an elevation of 1,900 feet, 350 feet above the surrounding plains. Several types of rhyolitic volcanics crop out on the mountain and in nearby hills eastward to the base of the Reagan Sandstone. Within this area a homoclinal sequence of rhyolite flows and tuffs nearly 3,600 feet thick can be measured. Concordant flow planes in lavas and bedding planes in water-laid tuffs reveal dip and strike. The following measured section is the type section of the Carlton Rhyolite Group (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 is Carlton Rhyolite Group (3,497 feet measured):

26. Rhyolite porphyry, reddish-brown, in part flow-banded and highly fractured. Strike N. 35° W., dip 41° NE on flow banding, thickness 225 feet.

25. Rhyolite porphyry, orange-red. Weathers into well-separated parallel layers, thickness 17 feet.

24. Single bed of completely flow-banded rhyolite containing euhedral feldspar phenocrysts ¼ to ½ inch long (Figs. 6 and 7). Strike

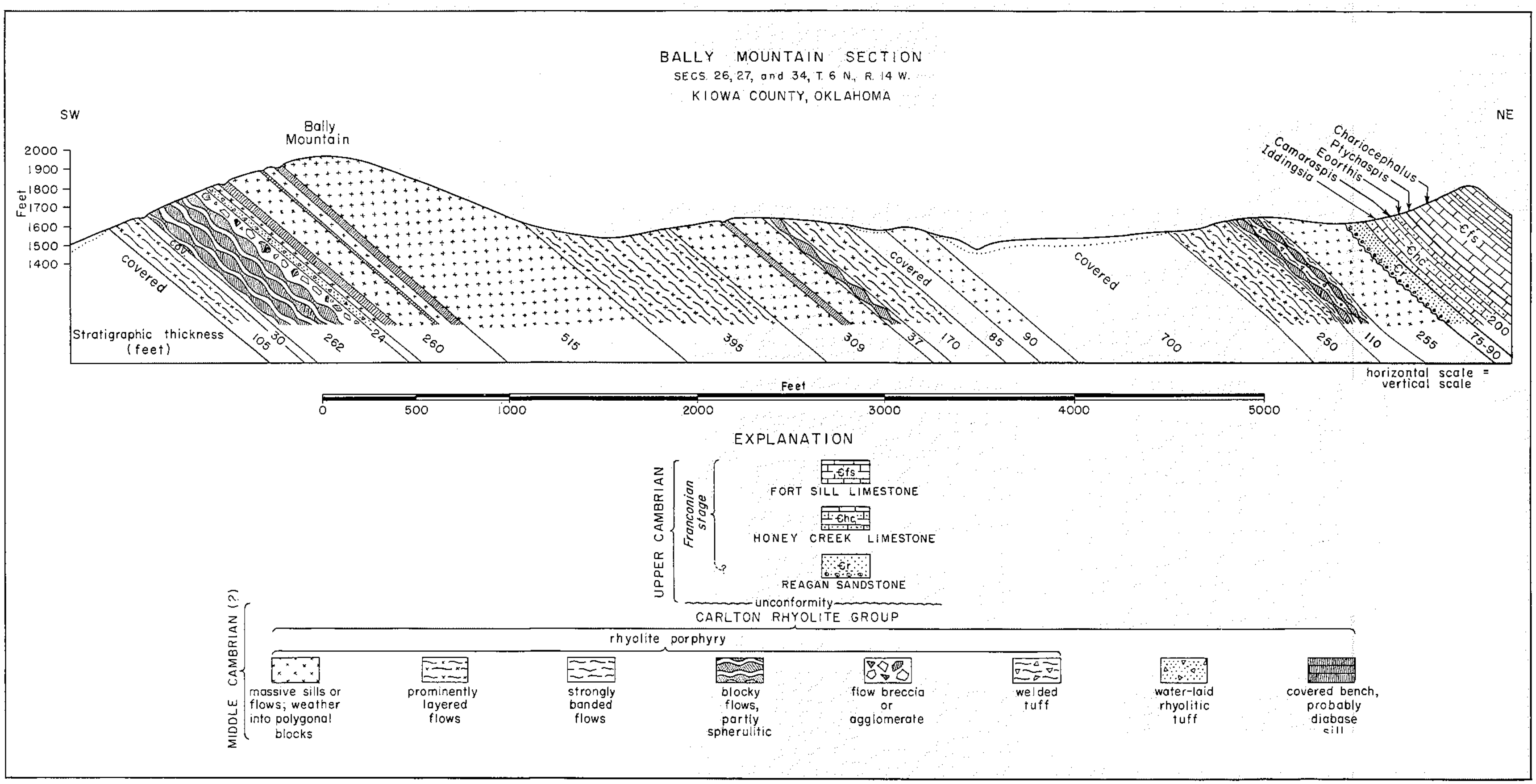

Figure 5. Measured section of Carlton Rhyolite Group at Bally Mountain.

N. 45° W., dip 35° NE, thickness 3.5 feet.

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, thickness 85 feet.

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, thickness 4.5 feet.

21. Rhyolite porphyry with definite but crudely defined flow and fluxion structure. Rocks are closely jointed. Reddish-brown groundmass encloses round 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, thickness 250 feet.

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, thickness 700 feet.

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

18. Covered by thick soil, thickness 85 feet.

17. Thinly sheeted and flow-banded rhyolite porphyry, many layers of which weather like thin-bedded sandstones (Fig. 8). Pink feldspar phenocrysts locally make up one-third of rock and are as much as ½ 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

Figure 6. Bed of strongly flow-banded rhyolite in upper part of Carlton Group, bed 24 of Bally Mountain measured section. View is toward northwest; Zodleton Mountain is on horizon at left.

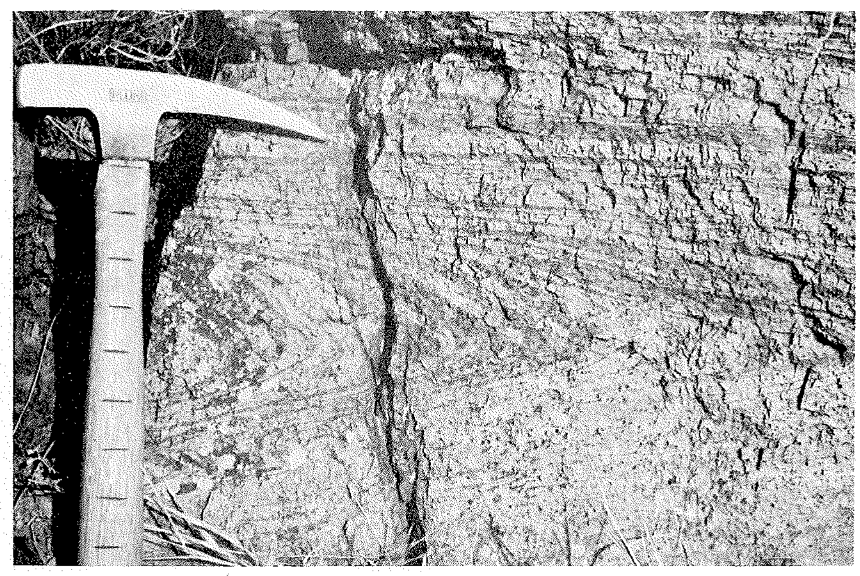

Figure 7. Detail of bed 24, showing parallel and contorted flow banding. Hammer handle is scale in inches.

Figure 8. Thinly sheeted and flow-banded rhyolite porphyry of the Carlton Group, bed 17 of the Bally Mountain measured section.

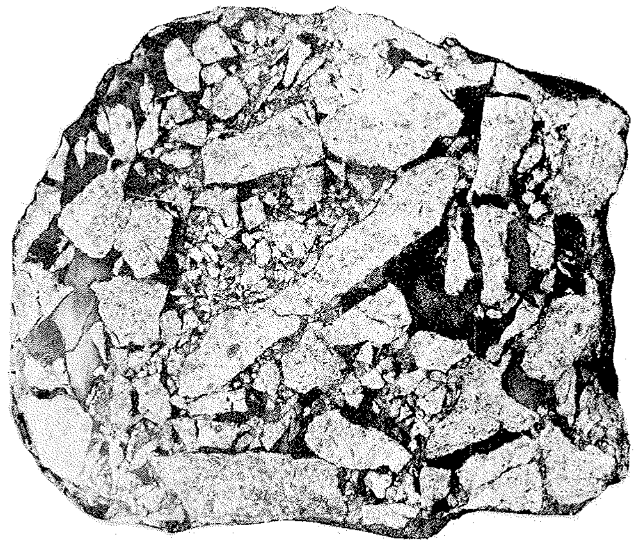

Figure 10. Rhyolite agglomerate in upper part of bed 3 of Bally Mountain measured section. Angular fragments of spherulitic rhyolite are in a matrix of devitrified shards and dust. The specimen is 4 inches long.

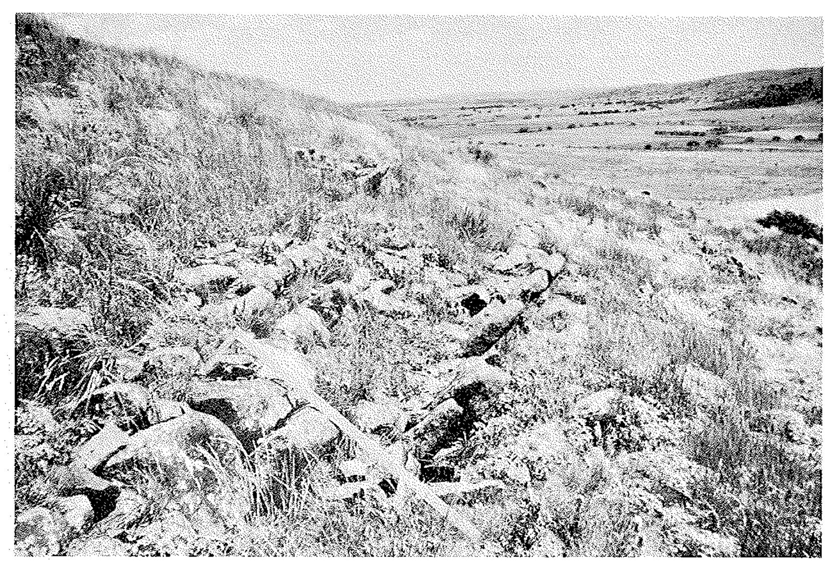

Figure 9. Beds of well-stratified rhyolite tuff, bed 4 of the Carlton Group, southwest face of Bally Mountain. Jacobs staff is 5 feet long.

by spherulitic coronas. The rock is probably a series of thin flows rather than welded tuff. Strike N. 35° W., dip 40° NE, thickness 170 feet.

16. Massive to spheroidal rhyolite porphyry, probably a blocky flow. Groundmass locally silicified and 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, thickness 37 feet.

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

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

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, thickness 182 feet.

12. Rhyolite porphyry, in part prominently layered and flow-banded. Quartz and feldspar phenocrysts abundant. Strike N. 35° W., dip 41° NE, thickness 395 feet.

11. Massive rhyolite porphyry weathering into smoothly jointed polygonal blocks. 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. Chemical analysis and isotopic age determinations of zircon made on rhyolite from this unit, thickness 515 feet.

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

9. Massive rhyolite, strongly sheeted and jointed, thickness 38 feet.

8. Covered bench, probably diabase or basalt, thickness 5 feet.

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

6. Covered bench, probably diabase or basalt, thickness 30 feet.

5. Massive closely jointed rhyolite, thickness 17 feet.

4. Rhyolitic tuff, dark reddish-brown, well-bedded, interstratified, medium- to fine-grained layers. Beds mostly 1 to 2 feet thick, weathering smooth and rounded (Fig. 9). In thin section: grains are subangular fragments, chiefly of perthite, devitrified spherulitic glass, and magnetite. Strike N. 30° W., dip 40° NE, thickness 24 feet.

3. Rhyolite porphyry grading into flow breccia and agglomerate (Fig. 10). 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, thickness 262 feet.

2. Covered on grassy slope, thickness 30 feet.

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.6N., R.14W., thickness 105 feet.

Covered by Permian red shales below. Measured thickness of Carlton Rhyolite Group 3,597 feet.

So far as can be ascertained, all the igneous rocks at Bally Mountain are of extrusive origin. They were deposited as flows and pyroclastics to form a volcanic accumulation probably a mile or more thick and covering at least 17,000 square miles. Rhyolitic volcanics were the principal rocks covering much of southern Oklahoma in Late Cambrian, and marine strata of the Reagan, Honey Creek, and Arbuckle units were subsequently deposited upon them. The Upper Cambrian sedimentary strata show the same dip and strike as the Middle Cambrian rhyolite (Fig. 5). Structural concordance allowed both the volcanic and the overlying sedimentary sequences to yield by the same style of folding during the later Pennsylvanian orogenies.

The general nature of the rocks that underlie Carlton rhyolite on the south flank of the Anadarko basin has been inferred from data collected in the Perdasofpy well (Fig. 11) as part of an intensive program of geophysical research (Widess and Taylor, 1959). The upper 4,000 feet of the basement sequence is drilled and known to be mainly rhyolite underlain by basalt. Approximately the next 16,000 feet consists of layered rocks that give seismic patterns suggestive of flows or bedded sediments. At least part of this undrilled sequence is believed to be graywacke of the Tillman Group, which is known to cover a large area in the subsurface south of the Wichita Mountains. The 20,000 feet of layered basement rocks at and near the Perdasofpy well is on the margin of the Anadarko basin, and can probably be projected into deep subsurface below the 40,000 feet of Paleozoic sediments previously known in that basin.

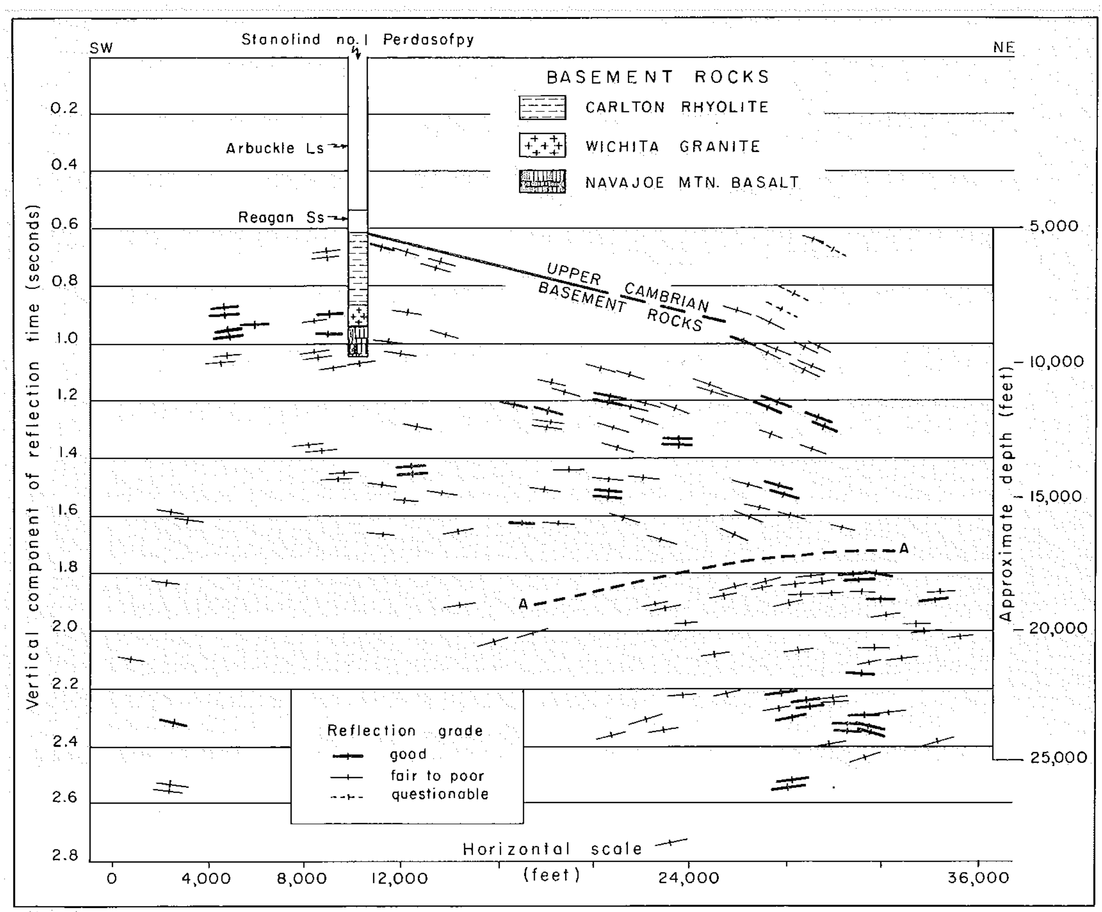

Figure 11. Seismic interpretation at the Stanolind 1 Perdasofpy well, sec. 11, T. 4 N., R. 12 W., slightly modified from Widess and Taylor (1959). The layered character of the basement rocks, including rhyolite, basalt, and probably graywacke, is here defined on the south flank of the Anadarko basin.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

STOP 4: IRA SMITH GRANITE QUARRY (LUNCH STOP), SW¼ SE¼ SE¼ sec. 4, T. 3 N., R. 15 W., Comanche County (C. A. Merritt).

A variety of Mt. Scott Granite is very well exposed in the Ira Smith quarry, and large surfaces of unaltered, massive, pink granite may be closely examined on quarried blocks. A principal reason for quarrying in this location is the relatively wide spacing of joints in the granite. Conspicuous weathering rinds are exhibited in cross section by some blocks which formed part of the weathering surface prior to quarrying. Small dark xenoliths of partly assimilated gabbroic rocks are widely scattered in the granite of the quarry, and some small quartz veins and pegmatitic dikes transect the granite.

Unlike most examples of Mt. Scott Granite, the rock at the Ira Smith quarry is not granophyric. The mode of a sample collected from the quarry by W. E. Ham and C. A. Merritt is: perthite, 59.4%; quartz, 29.3%; albite (An_8), 5.3%; hornblende, 3.6%; magnetite and ilmenite, 1.4%; sphene, 0.5%; riebeckite, 0.4%; zircon, 0.1%; and traces of aegerine, hematite, fluorite, and apatite. In addition to this mode, a chemical analysis and CIPW norm of the same sample (M-1) were reported by Merritt (1965, p. 265).

RAGGEDY MOUNTAIN GABBRO GROUP

by

Hugh E. Hunter

Introduction

The term "Raggedy Mountain Gabbro Group" has been applied to the gabbros and allied basic rocks of the Wichita province. Gabbroic rocks are exposed at several localities in the Wichita Mountains, the largest area of exposure comprising the Raggedy Mountains which lie in the central part of the Wichita system and for which the Group was named. Data from surface mapping and from subsurface studies (Ham, Denison, and Merritt, 1964) indicate that the gabbroic rocks constitute a stratiform body at least 25 miles wide and 110 miles long which extends along the northwest-trending axis of the Wichita Mountains. Surface mapping in the Raggedy Mountains area suggests an exposed thickness of approximately 600 feet. One well, which penetrated slightly more than 8000 feet of gabbroic rocks similar in mineralogical and textural characteristics to those exposed in the Raggedy Mountains, did not reach the lower contact. The thickness of the body is, therefore, unknown.

Detailed mapping by Gilbert (1960) and Spencer (1961) in the Raggedy Mountains and reconnaissance work by Spencer and Hunter in the eastern Wichita Mountains have shown that the main part of the gabbroic rocks consists of interlayered anorthosite, gabbro, olivine gabbro, and troctolite. The rocks exhibit features typical of a layered basic intrusive complex, and are designated "the layered series" of the gabbro group.

Dikes and sills of fine to medium-grained olivine gabbro intrude the layered series, and are in turn cut by younger dikes and sills of microdiorite. Granite and aplite intrude the basic and intermediate rocks, and locally form extensive areas of mixed rock consisting of intrusion breccias and assimilation products. These intrusive rocks are designated "the intrusive group". Rock units mapped in the Raggedy Mountains are shown in Table 3.

TABLE 3. Rock Units Mapped in the Raggedy Mountains

Intrusive Group	Granite - Aplite	Mixed Rock
	Microdiorite	Mixed Rock
	Biotite Olivine Gabbro - Olivine Microgabbro	
Layered Series	M-zone	
	L-zone	
	K-zone	
	G-zone	

The Layered Series

Minerals of the layered series are plagioclase, monoclinic pyroxene (diallage), olivine, orthorhombic pyroxene (hypersthene), titaniferous magnetite, and traces of hornblende and apatite in some specimens. Rhythmic layering is conspicuous in many localities due to abrupt changes in the proportions of feldspar and ferromagnesian minerals. Layers or bands of anorthosite, gabbro, olivine gabbro, and troctolite, ranging from less than one inch to tens of feet in thickness can be observed in individual outcrops. Igneous lamination defined by preferred planar orientation of tabular plagioclase crystals is striking in some outcrops, and is present to some degree in all rocks in which the tabular habit of the plagioclase is well developed. Rhythmic layering and igneous lamination have had a marked influence on the topography of the area, and the gabbroic rocks exhibit erosional features generally associated with sedimentary strata.

Four stratigraphic units or zones have been mapped in the layered series; anorthosite is the predominant rock type. Along the southern margin of the Raggedy Mountains and in the area immediately south of Roosevelt, Oklahoma, significant amounts of troctolite and lesser amounts of diallage gabbro and olivine gabbro are interlayered with anorthosite. These rocks have been designated the "K-zone". Rocks stratigraphically above the K-zone comprise anorthosite with diallage gabbro and minor olivine gabbro and troctolite. Differences in textures of plagioclase-pyroxene intergrowths have been used to subdivide these rocks into the "L-zone" and the "M-zone". These subdivisions show consistent stratigraphic relationships in the western Raggedy Mountains, but the L-zone is not exposed east of sections 19 and 30, T.4 N., R.17 W. Troctolite with a high proportion of titaniferous magnetite is exposed at Iron Mountain, a low hill lying on the township line separating T.4 N., R.16 W. and T.4 N., R.17 W., and has been mapped as the "G-zone". The chief characteristics of rocks of the four zones are shown in Table 4.

TABLE 4. Characteristics of Rocks in Zones of the Layered Series

M-zone:	Predominantly anorthosite; lenses, layers, and irregular areas of gabbro and olivine gabbro; some lenses of troctolite; plagioclase-pyroxene intergrowths have fine ophitic texture.
L-zone:	Predominantly anorthosite; irregular areas of diallage gabbro; rare lenses of troctolite; plagioclase-pyroxene intergrowths have coarse ophitic texture.
K-zone:	Alternating layers of anorthosite and troctolite; coarse ophitic pyroxene at some horizons; olivine with poikilitically included plagioclase rimmed by spinel-orthopyroxene intergrowths.

G-zone: Medium-grained troctolite with 5 to 15 per cent titaniferous magnetite.

K-zone. Rocks of this unit occupy the lowest established stratigraphic position in the layered series. The zone is at least 120 feet thick, but the lower contact has not been observed. The rocks consist primarily of many alternating bands of anorthosite and troctolite with masses of coarse ophitic pyroxene sporadically distributed in the layers. Rhythmic layering is pronounced, and igneous lamination, in which the plane of preferred orientation of tabular plagioclase crystals is parallel to the layers, is evident in most outcrops. Plagioclase (An_{70-75}), olivine (Fo_{65-67}), diallage, and titaniferous magnetite are the principal minerals. Most olivine grains enclose numerous fine laths of randomly oriented plagioclase and are surrounded by partial or complete rims of orthopyroxene and/or symplectites of black spinel and orthopyroxene.

L-zone. This zone consists primarily of anorthosite in which large diallage crystals are irregularly distributed. Locally the anorthosite grades to diallage gabbro or is interlayered with minor olivine gabbro or troctolite. Rhythmic layering is rare in this zone, but igneous lamination is pronounced in most outcrops. The most striking characteristic of the zone is the presence of ophitic plagioclase-pyroxene intergrowths ranging up to 30 cm in diameter; pyroxene in crystallographically continuous masses encloses numerous plagioclase laths. In grain size, composition, and degree of preferred planar orientation, the enclosed plagioclase is identical with that external to the pyroxene. Plagioclase (An_{70-75}) and diallage are the principal minerals with minor hypersthene, olivine (Fo_{65-67}), and titaniferous magnetite.

M-zone. The M-zone is distinguished from the underlying L-zone by generally finer grain size, greater variety of rock types, and by the textural characteristics of plagioclase-pyroxene intergrowths. As in the L-zone, pyroxene crystals are rather large (0.6 to 13 cm in diameter), nearly spherical and enclose numerous grains of plagioclase. Plagioclase within the pyroxene is anhedral, randomly oriented, and generally finer grained than that external to the pyroxene. The composition of plagioclase enclosed within pyroxene was compared with that of external plagioclase in eight specimens; in six of these specimens, enclosed plagioclase is more sodic (An_{50-60}) than external plagioclase (An_{70-75}). Olivine (Fo_{65-67}) is more abundant than in the L-zone, generally as fine grains intergrown with plagioclase, but also as cores within larger pyroxene grains.

The genetic significance of the different plagioclase-pyroxene intergrowths is not clear. It is evident that the large masses of pyroxene in the L-zone grew as interprecipitate crystals interstitial to feldspars which had attained planar orientation probably under the influence of gravity. Textures in the M-zone suggest cotectic crystallization of plagioclase and pyroxene.

G-zone. Outcrops of this zone are confined to the slopes of Iron Mountain and to small exposures in nearby low areas. The rock is medium-grained troctolite which contains 5 to 15 per cent titaniferous magnetite. The principal minerals are plagioclase (An_{70-75}), olivine (Fo_{65-67}), and titaniferous magnetite. The texture is xenomorphic, and olivine grains lack the reaction rims and symplectites that are common in the other zones.

The stratigraphic position of the G-zone is not established. Plagioclase and olivine have approximately the same compositions as in other zones, and the rocks are obviously closely related. A well-defined, linear structural trend extending northwest-southeast lies immediately west of Iron Mountain and may represent a fault trace along which vertical movement has taken place. The G-zone is tentatively placed below the K-zone stratigraphically.

Intrusive Group

Biotite Olivine Gabbro-Olivine Micrograbbro. Medium-grained, biotite-bearing olivine gabbro occurs sporadically throughout the area as narrow, linear outcrop bands. Some of the bands are concordant with layering but some are discordant. A definite intrusive relationship is illustrated in a road cut in the SE¼ sec. 19, T.4 N., R.16 W., where a dike of biotite olivine gabbro intrudes rocks of the L-zone and encloses xenoliths of anorthosite (Stop 5). The rock contains plagioclase (An_{55-60}), diallage, olivine (Fo_{50-55}), biotite, and appreciable brown hornblende, apatite, and titaniferous magnetite. Other dikes and sills which crosscut the layered series consist of fine-grained olivine gabbro (microgabbro) which differs mineralogically from the biotite olivine gabbro in the absence of biotite and hornblende and in the somewhat more magnesian composition of the olivine (Fo_{55-60}).

Microdiorite-Aplite Mixed Rock. Dikes and sills of fine-grained, dense, black microdiorite are numerous in the western part of the Raggedy Mountains and occur with decreasing frequency toward the east. Most of the intrusions are sill-like and appear to have followed zones of weakness in the layered series parallel to the planes of rhythmic layering and igneous lamination. A vertical dike of microdiorite approximately 50 feet wide can be traced for 3 miles along an east-west strike in the eastern Raggedy Mountains. The microdiorite contains andesine and blue-green hornblende, and minor quartz in some specimens.

Aplite and granitic material occur primarily in association with microdiorite and have been intruded generally along the same planes of weakness followed by the microdiorite. Extensive outcrops in the western Raggedy Mountains show microdiorite and granitic material complexly intermingled. In some localities, aplite and granite enclose xenoliths of microdiorite forming intrusion breccia in which little or no alteration of microdiorite has occurred. In other places, however, assimilation of microdiorite by granitic material has formed extensive bodies of hybrid rock.

The Eastern Wichita Mountains

Reconnaissance work indicates that the relationships established in the Raggedy Mountains are, in general, valid throughout the exposed part of the Raggedy Mountain Gabbro Group. However, medium-grained diorite to quartz diorite that does not correspond to any unit of the layered series has been observed in the Mount Sheridan-Mount Scott area. These rocks crop out beneath a cap of granite on Mount Sheridan and at the base of Mount Scott. Subsurface studies show a rather widespread occurrence of similar rocks, which characteristically occur beneath granite and above gabbro. It is suggested that the diorite is a late differentiate of the magma which produced the layered series.

In the valley north of Mount Sheridan (SE¼ sec. 32, T.4 N., R.13 W.), medium-grained diorite similar to that exposed in the quarries on Little Mount Sheridan intrudes anorthosite and gabbro which resemble rocks of the L-zone of the Raggedy Mountains area, and which are certainly part of the layered series; this suggests that the relative age of the diorite is similar to that of the microdiorite in the Raggedy Mountains. The diorite of the Mount Sheridan area is more closely allied mineralogically to the microdiorite than to the layered series. It may well be a differentiate of the gabbro magmas, but, alternatively, could be genetically related to the granitic rocks of the area. More work is needed to clarify the relationships between the diorite and other rocks of the Wichita Mountains.

STOP 5: DIKE OF BIOTITE OLIVINE GABBRO, SE¼ SE¼ sec. 19, T. 4 N., R. 16W., Kiowa County (H. E. Hunter and G. T. Stone)

A dike of biotite olivine gabbro approximately thirty feet wide is exposed along the northwest face of the roadcut. The dike is almost vertical and strikes approximately N.65° E. (Spencer, 1961). It intersects the road at a low angle and consequently has a broad outcrop in the roadcut. The dike rock is generally somewhat altered and is easily disaggregated. The primary minerals may be recognized most readily in less altered residual spheroids which protrude as knobs. Bronze biotite and drab-green diallage are conspicuous; olivine is dark due to oxidation.

The dike cuts anorthosite of the L-zone, part of the layered series of the Raggedy Mountain Gabbro Group, and contains numerous xenoliths of anorthosite. The discordant contact and the xenoliths clearly demonstrate the intrusive nature of the biotite olivine gabbro. Moreover, dikes of microdiorite and aplite intrude biotite olivine gabbro; the aplite appears to be the youngest.

The hill immediately to the north consists of anorthositic rocks of the L-zone (coarse ophitic texture) which exhibit igneous lamination defined by preferred orientation of tabular plagioclase crystals. The lamination strikes east-west and dips approximately 17° to the north (Spencer, 1961). The north side of the hill is a dip slope which roughly parallels the lamination.

Anorthositic rocks of the M-zone (fine ophitic texture) crop out south of the road. Immediately to the west, they form the southwest slope of the hill and are exposed on a small knob. The stratigraphically higher rocks of the M-zone apparently were dropped down against L-zone rocks along an east-west fault which passes through the low saddle on the north side of the knob (Spencer, 1961).

STOP 6: INTRUSION BRECCIA, NE¼ sec. 21, T. 4 N., R. 17 W., Kiowa County (C. A. Merritt)

This outcrop is typical of the intrusion breccias which are exposed in several localities in the west-central Wichita Mountains. Some of the outcrops comprise many acres. The intrusion breccia is a mixture of granite and microdiorite. The microdiorite was apparently intruded as a widespread sill into the layered series of the Raggedy Mountain Gabbro Group. Microdiorite also occurs as dikes up to three or more miles in length, and is interpreted as a late differentiation product of the basaltic magma which formed the layered series. The microdiorite sill was intruded by granitic magma, probably magma of the Mt. Scott Granite, and formed an intrusion breccia. Some assimilation occurred with the formation of a gray granite-like hybrid rock; this hybrid rock is known as Cold Springs Granite.

An abandoned quarry at Round Mountain 2 miles west of this outcrop shows a layer of intrusion breccia underlain by Cold Springs Granite. Faint outlines of assimilated microdiorite (shadow inclusions) may be seen in the quarry face. Thin sections of the hybrid rock contain both oligoclase (An_{38}) and andesine (An_{47}); the latter is a relict mineral from the microdiorite. The Cold Springs "granite" actually varies in composition from hornblende granite through quartz monzonite and granodiorite to quartz diorite. Being a contaminated rock, its composition depends upon the amount and degree of assimilation of microdiorite.

STOP 7: RHYTHMIC LAYERING OF TROCTOLITE AND ANORTHOSITE, NE$\frac{1}{4}$ sec. 21, T. 4 N., R. 17 W., Kiowa County (H. E. Hunter and G. T. Stone)

A few hundred yards southeast of Stop 6, a sequence of strata is exposed on the south-facing scarp slope of a low ridge. The layered rocks strike east-west and dip gently to the north (Gilbert, 1960). In crossing a small valley, the exposures of the cuesta form a prominent "V", which points downdip. Although resembling sedimentary rocks from a distance, this sequence is actually a typical K-zone troctolite-anorthosite assemblage in the layered series of the Raggedy Mountain Gabbro Group. Rhythmic layering of plagioclase and olivine is pronounced, and igneous lamination defined by preferred orientation of tabular plagioclase crystals is especially prominent. Large masses of diallage occur locally in the anorthositic bands.

Eight layered units have been mapped in this locality. In ascending stratigraphic order, they are: troctolite 1, troctolite 2, anorthositic gabbro 1, thin-bedded interlayered troctolite and anorthositic gabbro, anorthositic gabbro 2, olivine gabbro 1, anorthositic gabbro 3, and olivine gabbro 2 (Rotan, 1960).

The soil covered slopes to the north and west are underlain by anorthositic rocks of the L-zone. (These rocks are exposed in a small excavation on the west side of the low hill immediately southeast of Stop 6.) The prominent ridge less than a mile to the north has L-zone rocks at its base below K-zone troctolite-anorthosite which is overlain by rocks of the L-zone. Apparently the anorthositic rocks at the base of the ridge were dropped down against K-zone rocks along an east-west fault (Gilbert, 1960).

SELECTED REFERENCES

Chase, G. W., 1950a, The igneous rocks of the Roosevelt area, Oklahoma: M. S. Thesis, Univ. Oklahoma, 108 p.

_____ 1950b, Geologic map of the basic igneous rocks in the Raggedy Mountains, Wichita Mountain system, Oklahoma: Okla. Geol. Survey, Prelim. Map A-1.

_____ 1954, Permian conglomerate around Wichita Mountains, Oklahoma: Am. Assoc. Petroleum Geologists Bull., v. 38, p. 2028-2035

_____ Frederickson, E. A., and Ham, W. E., 1956, Resume of the geology of the Wichita Mountains, Oklahoma *in* Petroleum geology of southern Oklahoma -- a symposium, v. 1: Ardmore Geol. Soc., p. 36-55.

Denison, R. E., Hetherington, E. A., Jr., and Kenny, G. S., 1966, Isotopic-age dates from basement rocks in Oklahoma: Okla. Geol. Survey, Okla. Geology Notes, v. 26, p. 170-176

Frech, R. E., 1962, Basic rocks of the Roosevelt-Cold Springs area, southwestern Oklahoma: M. S. Thesis, Univ. Oklahoma, 46 p.

Gilbert, M. C., 1960, The geology of the western Glen Mountains, Oklahoma: M. S. Thesis, Univ. Oklahoma, 48 p.

Ham, W. E., 1963, Basement rocks and structural evolution of southern Oklahoma: Ardmore Geol. Soc, Field Conference Guidebook, 51 p.

_____ Denison, R. E., and Merritt, C. A., 1964, Basement rocks and structural evolution of southern Oklahoma: Okla. Geol. Survey, Bull. 95, 302 p.

_____ Merritt, C. A., and Frederickson, 1957, Geology of the Wichita Mountain region: Okla. Geol. Survey Guidebook 5, 58 p.

Hamilton, W. B., 1956, Precambrian rocks of Wichita and Arbuckle Mountains, Oklahoma: Geol. Soc. America Bull., v. 67, p. 1319-1330.

_____ 1959, Chemistry of granophyres from Wichita lopolith, Oklahoma: Geol. Soc. America Bull., v. 70, p. 1119-1125.

Harlton, B. H., 1963, Frontal Wichita fault system of southwestern Oklahoma: Am. Assoc. Petroleum Geologists Bull., v. 47, p. 1552-1580.

Hiss, W. L., 1960, Ferromagnesian minerals in basic igneous rocks, Raggedy Mountains area, Wichita Mountains, Oklahoma: M. S. Thesis, Univ. Oklahoma, 104 p.

_____ and Hunter, H. E., 1966, Primary orthopyroxene-spinel intergrowths in Cambrian cumulates, Wichita Mountains, Oklahoma: Okla. Geol. Survey, Okla. Geology Notes, v. 26, p. 231-235.

Hoffman, M. G., 1930, Geology and petrology of the Wichita Mountains: Okla. Geol. Survey, Bull. 52, 83 p.

Huang, W. T., 1955, Occurrences of leucogranogabbro and associated igneous rocks in the Wichita Mountains, Oklahoma: Am. Jour. Sci., v. 253, p. 341-357.

_____ and Merritt, C. A., 1954, Petrography of the troctolite of the Wichita Mountains, Oklahoma: Am. Mineralogist, v. 39, p. 549-595.

Hunter, H. E., 1962, Layered basic intrusive rocks of the Wichita Mountains, S. W. Oklahoma (Abstract): Am. Mineralogist, v. 47, p. 192 (also Min. Soc. America Special Paper 1, p. 134).

Johnson, H. D., 1960, Mineralogical study of altered basic intrusive rocks, Wichita Mountains, Oklahoma: M. S. Thesis, Univ. Oklahoma, 62 p.

Karns, A. W. W., 1961, Ophitic pyroxene from the Raggedy Mountains area, Wichita Mountains, Oklahoma: M. S. Thesis, Univ. Oklahoma, 68 p.

Merritt, C. A., 1965, Mt. Scott Granite, Wichita Mountains, Oklahoma: Okla. Geol. Survey, Okla. Geology Notes, v. 25, p. 263-272.

_____ 1966, Names and relative ages of granites and rhyolites in the Wichita Mountains, Oklahoma: Okla. Geol. Survey, Okla. Geology Notes, v. 27, p. 45-53.

Nichols, C. R., in preparation, Processes and products of alteration of igneous rocks, Kiowa County, Oklahoma: M. S. Thesis, Univ. Oklahoma

Rotan, P. M., 1960, Preferred orientation of plagioclase in basic rocks, Raggedy Mountains, southwestern Oklahoma: M. S. Thesis, Univ. Oklahoma, 62 p.

Spencer, A. B., 1961, Geology of the basic rocks of the eastern portion of the Raggedy Mountains, southwestern Oklahoma: M. S. Thesis, Univ. Oklahoma, 46 p.

Tilton, G. R., Wetherill, G. W., and Davis, G. L., 1962, Mineral ages from the Wichita and Arbuckle Mountains, Oklahoma, and the St. Francis Mountains, Missouri: Jour. Geophys. Research, v. 67, p. 4011-4019.

Walper, J. L., 1951, Assimilation in the Cold Springs area of the Wichita Mountains igneous complex, Oklahoma: Am. Jour. Sci., v. 249, p. 47-65.

Widess, M. B., and Taylor, G. L., 1959, Seismic reflections from layering within the Precambrian basement complex, Oklahoma: Geophysics, v. 24, p. 417-425.