OKLAHOMA GEOLOGICAL SURVEY

GUIDE BOOK V

FIELD CONFERENCE

ON

GEOLOGY OF THE WICHITA MOUNTAIN REGION

MAY 2-4, 1957

BY

WILLIAM E. HAM

CLIFFORD A. MERRITT

E. A. FREDERICKSON

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PANHANDLE GEOLOGICAL SOCIETY

UNIVERSITY OF OKLAHOMA

OKLAHOMA GEOLOGICAL SURVEY

NORMAN

1957

FIELD CONFERENCE

ON

GEOLOGY OF THE WICHITA MOUNTAIN REGION

IN

SOUTHWESTERN OKLAHOMA

MAY 2, 3, AND 4, 1957

BY

WILLIAM E. HAM
OKLAHOMA GEOLOGICAL SURVEY
(LEADER ON PERMIAN AND ORDOVICIAN ROCKS)

CLIFFORD A. MERRITT
UNIVERSITY OF OKLAHOMA
(LEADER ON PRECAMBRIAN ROCKS)

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(LEADER ON CAMBRIAN ROCKS)

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OKLAHOMA GEOLOGICAL SURVEY

CARL C. BRANSON, DIRECTOR

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To Louise Jordan, geologist, Oklahoma Geological Survey, special thanks are expressed for the descriptions of oil and gas fields along the trip routes, and for the general information on subsurface geology.

SCHEDULE

THURSDAY, MAY 2

9:45 A.M. TO 11:45 A.M.	Registration The American Legion Hall, Sayre, Oklahoma.
11:45 A.M.	Caravan assembles at east edge of Sayre.
12:00 Noon	Caravan leaves Sayre.
6:00 P.M.	Caravan arrives at Quartz Mountain Lodge.
7:30 P.M.	Banquet – Quartz Mountain Lodge Dining Room.

FRIDAY, MAY 3

7:45 A.M.	Caravan assembles along road leaving Quartz Mountain Lodge.
8:00 A.M.	Leave Quartz Mountain Lodge.
12:30 P.M.	Lunch in field.
6:00 P.M.	Caravan arrives at Lawton, Oklahoma.

SATURDAY, MAY 4

7:45 A.M.	Caravan assembles along edge of highway at intersection of U. S. Highways 62-277-281 with State Highway 49, 7.5 miles north of Lawton.
8:00 A.M.	Caravan leaves assembly area.
12:00 Noon	Field trip disbands.

FIELD TRIP ENDS

GENERAL INSTRUCTIONS

1. The starting time of 12:00 noon of the first day and 8:00 A.M. of the following days is the time of departure of the caravan. Please assemble 15 minutes early to insure prompt departure.
2. Each car should be in line according to the designated car numbers.
3. Do not pass other caravan cars on the highway.
4. In the event of mechanical difficulties, pull off the road so that other cars may pass. There will be a special car at the end of the caravan to aid cars in distress.
5. WARNINGS IN THE ROAD LOGS ARE IN CAPITALS. Give them your attention.
6. Please observe the instructions of the flagmen at the various stops.

FIRE WARNING -- PLEASE DO NOT DISCARD MATCHES OR CIGARETTES FROM CAR WINDOWS OR AT STOPS. -- STATE LAW!!

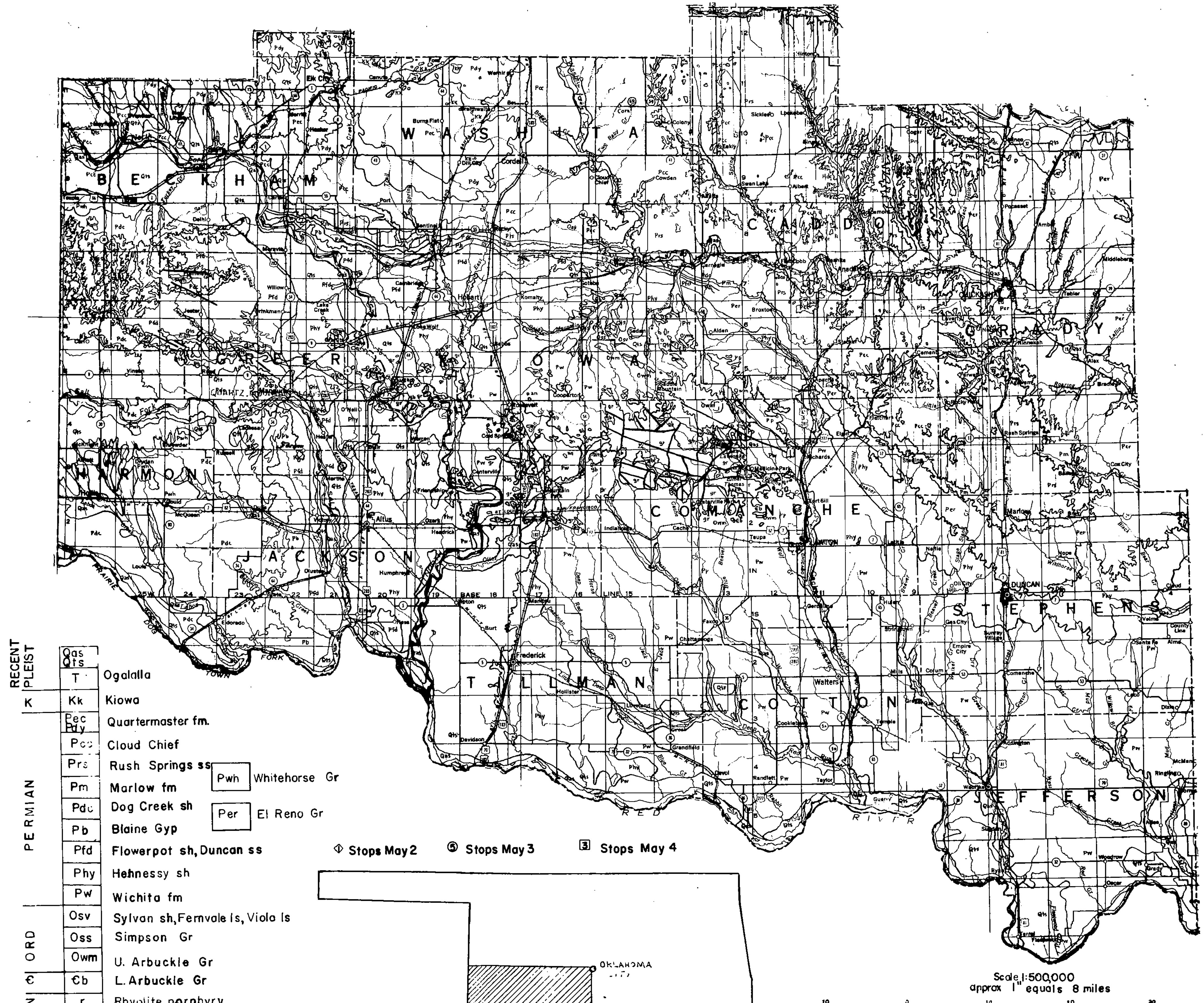
Table of Outcropping Rocks in Wichita Mountain Region

System	Group or formation	Formation or member	Thickness (feet)	
Permian	Quartermaster fm.	Elk City ss., Pec.	170	
		Doxey sh., Pdy	160-200	
	Cloud Chief fm., Pcc		250-300	
	Whitehorse group	Rush Springs ss., Prs.	160-300	
		Marlow fm., Pm	100—130	
	El Reno Group	Dog Creek sh., Pdc.	80-150	Duncan-Chickasha 650'
		Blaine fm., Pb	80-150	
		Flowerpot sh., Pf	165	
		Duncan ss., Pd	30-125	
	Hennessey shale, Phy		400-600	
	Wichita fm., Pw	Garber ss. and equivalents	300	1,700 outcrop; 6,000 subsurface
		Wellington equivalents. Contains Post Oak cgl. member derived locally from Wichita Mountains	500-700 outcrop; 2,000 subsurface	
		Stratford (upper Pontotoc) equivalents	900 outcrop; 3,500 subsurface	
Ordovician	Viola ls.		575	
	Simpson group, Bromide fm.		86 exposed	
	Arbuckle group	West Spring Creek fm.	1,400? (300' exposed)	
		Kindblade fm.	1,400	
		Cool Creek fm.	1,100	
		McKenzie Hill fm.	1,050	
Cambrian		Signal Mountain fm.	400	
		Royer dolomite	195	
		Fort Sill fm.	350	
	Timbered Hills group	Honey Creek fm.	200-300	
		Reagan ss	50-150	

Precambrian

Western Area *	Eastern area *
Dike rocks	Dike rocks
Lugert granite	Quanah granite
Reformatory granite	"Lugert" granite
Headquarters granite	Carlton rhyolite
Andesite	Andesite
Gabbro-anorthosite	Gabbro-anorthosite
	Meers quartzite

* General scheme of principal rocks is shown. Several rocks of small outcrop area, some of which have been named, are not included.



GEOLOGIC MAP OF WICHITA MOUNTAIN REGION
SHOWING ROUTE OF FIELD TRIP
(Adapted from Geologic Map of Oklahoma, 1954)

ASSEMBLY POINT - The caravan will assemble on State Highway 152 (formerly State Highway 41) on the east edge of Sayre. The lead car should be parked approximately 100 yards east of the Sayre Pentecostal Church and the following cars in order of assigned numbers closing in behind. Cars should be parked as far onto the shoulder of the road as feasible.

Mileage From		
Start	Last entry	
0.0	0.0	Sayre Pentecostal Church, east edge of Sayre. Caravan heads east on State Highway 152. Sandy flood plain of North Fork of Red River to south.

SAYRE DISTRICT

The Sayre district, three miles south of the town of Sayre, is the oldest gas-producing area in Beckham County. Production is from Permian dolomite at the base of the Wellington exhibiting a slight domal structure. In 1922, a local group brought in the discovery well (SW one-quarter SE one-quarter 5-9N-23W). The initial production was 50 million cubic feet of gas and 20 barrels of oil from 2,755 to 2,906 feet. In April 1923, an oil well with the initial production of 200 barrels of 35 degree gravity oil from 2,995 in NE one-quarter SE one-quarter NW one-quarter Section 31 created interest in the area. In July of the same year Carter Oil Company completed a 2000-barrel well in a north offset to the discovery well. At the end of 1926, only two wells were producing oil and total production from eight wells which had been completed in Sections 15, 31 and 32 was 301,766 barrels. Four wells apparently drilled in 1952-53 in Section 31 are reported to be producing oil from granite wash at an average depth of 2,980 feet. At the end of 1955 cumulative production was 41,445 barrels of 37 degree gravity oil from 120 acres.

0.7	0.7	Cloud Chief outcrops in roadcut.
0.4	1.1	Cloud Chief outcrops in roadcut.
0.7	1.8	Cloud Chief outcrops in roadcut.
1.3	3.1	Timber Creek. Doxey shale exposed in stream banks.
0.5	3.6	Base of Doxey crops out in low rounded hills.
0.4	4.0	Uppermost beds of Cloud Chief, composed of gypsiferous sandstone and shale, exposed in ravine to south.
1.0	5.0	STOP 1. Doxey shale. NW one-quarter NE one-quarter, 5-9N-22W.

The Doxey shale is well exposed in ravines on south side of road. The basal member of the Quartermaster formation of probable upper Permian age, the Doxey is here shown in typical outcrop, consisting of reddish brown shale, mudstone, thin siltstones and thin fine-grained sandstones. Normal thickness of the Doxey in western Oklahoma is 160-200 feet.

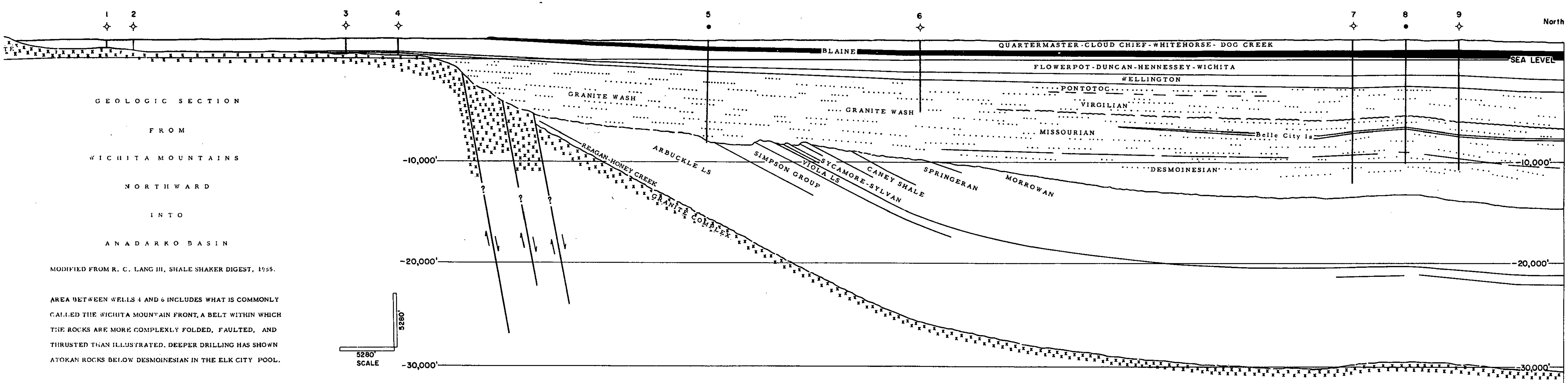
Of particular interest at this locality are the abrupt changes in dip and strike which are the result of slumping due to solution of gypsum beds in the underlying Cloud Chief and Blaine formations. Although the regional dip here is northward toward the axis of the Anadarko Basin, the local dip shows

A WIDE RANGE FROM NORTHWEST THROUGH SOUTHEAST TO NORTHEAST, THE GREATEST DIP ANGLE OF APPROXIMATELY 22 DEGREES BEING FOUND ON THE NORTHWEST FLANK OF WHAT IS APPARENTLY AN ANTICLINAL FOLD. SMALL HIGH-ANGLE NORMAL FAULTS WITH A DISPLACEMENT OF TWO TO SEVEN FEET MAY BE SEEN LOCALLY IN THE RAVINE WALLS. OF SEDIMENTATIONAL INTEREST IS THE OCCURRENCE OF RIPPLE MARKS AND BOTTOM SURFACE MARKINGS ON SOME SANDSTONE AND SILTSTONE BEDS. NO FOSSILS HAVE BEEN FOUND IN THE DOXEY AT THIS LOCALITY.

0.3	5.3	EXCELLENT EXPOSURES OF DOXEY IN RAVINES ON NORTH AND SOUTH SIDES OF HIGHWAY.
2.1	7.4	INTERSECTION WITH STATE HIGHWAY 34. CAUTION. TURN RIGHT (SOUTH).

ELK CITY FIELD

THE ELK CITY FIELD LIES 4 MILES NORTHEAST OF THIS INTERSECTION. IT IS ONE OF THE TWENTY "GIANT" OIL FIELDS OF OKLAHOMA, HAVING AN ULTIMATE RECOVERY OF MORE THAN 100 MILLION BARRELS OF OIL. PRODUCTION FROM THIS NORTHWESTERLY TRENDING ANTICLINAL STRUCTURE, WHICH NOW COVERS 7,680 ACRES, WAS DISCOVERED IN 1947 BY THE SHELL OIL COMPANY NO. 1 J. G. WALTER (C NE NW 14-10N-21W) HAVING AN INITIAL PRODUCTION OF 469 BARRELS OF 65 DEGREE A.P.I. DISTILLATE AND 5,736,000 CUBIC FEET OF GAS FROM 9,260 TO 9,360 FEET. SINCE THAT TIME NUMER-



GEOLOGIC SECTION

FROM

WICHITA MOUNTAINS

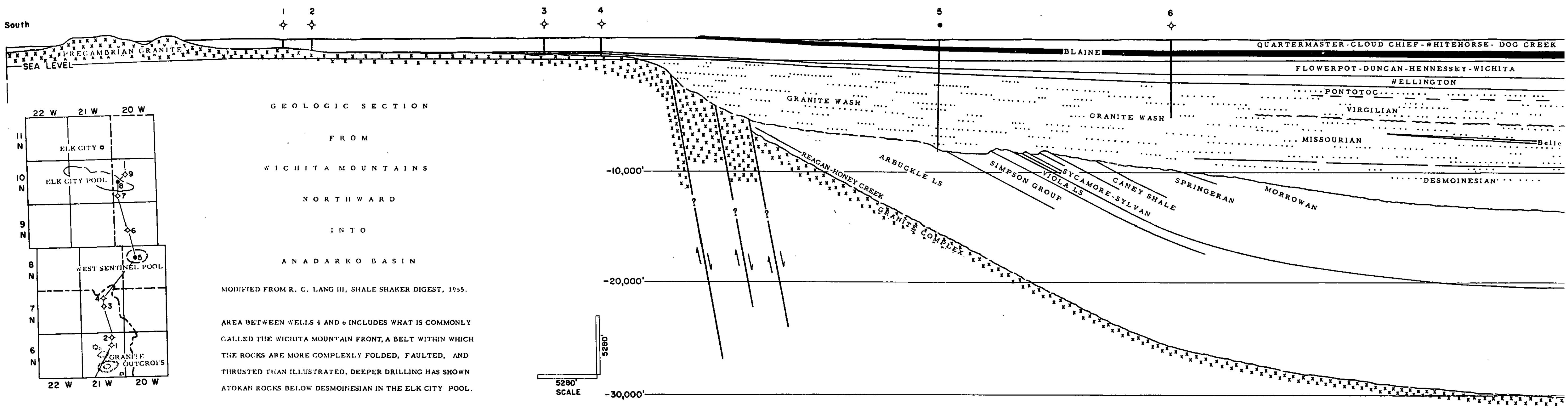
NORTHWARD

INTO

ANADARKO BASIN

MODIFIED FROM R. C. LANG III, SHALE SHAKER DIGEST, 1955.

AREA BETWEEN WELLS 4 AND 6 INCLUDES WHAT IS COMMONLY CALLED THE WICHITA MOUNTAIN FRONT, A BELT WITHIN WHICH THE ROCKS ARE MORE COMPLEXLY FOLDED, FAULTED, AND THRUSTED THAN ILLUSTRATED. DEEPER DRILLING HAS SHOWN ATOKAN ROCKS BELOW DESMOINESIAN IN THE ELK CITY POOL.



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our porous zones in arkosic sands and arkose ranging in depth from 8,800 to 11,800 feet have been found productive of oil, distillate, and gas. The age is primarily Missourian but extends downward into Desmoinesian.

During 1956 5,326,000 barrels of oil were produced from 307 wells over 7,700 acres. At the end of the year the cumulative production was 43,569,000 barrels and estimated reserves were 76,431,000 barrels. Average gravity of the oil is 61 degrees.

Shell-Carter No. 1 Caughron (C SE NW 19-10N-21W) on the southwest flank of the structure is the deepest test with depth of 15,625 feet having penetrated approximately 6,800 feet of Permian rocks and 8,825 feet of Pennsylvanian (Virgilian 2,080 feet; Missourian, 2,585; Desmoinesian, 1,980 feet; Atokan 2,180 feet).

Continental No. 1 Proctor (C NW Sec. 28-10N-20W), located on the southeast end of the structure and drilled before the discovery of the field, is reported to have reached Mississippian shale, total depth 14,592 feet. However, this age assignment is questioned.

0.2	7.6	Excellent Doxey outcrops in ravine to left.
1.25	8.85	Note steep north dip of Doxey in roadcut on left.
0.65	9.5	Doxey in roadcut on right.
0.9	10.4	Approximate Doxey-Cloud Chief contact. Mostly covered by high-terrace sands.
0.6	11.0	Sandstone and shale of Cloud Chief poorly exposed in fields on left.

0.9	11.9	MKT RAILROAD CROSSING- CAUTION.
0.4	12.3	Entering Carter. Two miles northwest Shell Oil Company will drill an 11,500 foot test at its No. I-B Boyd unit, C NW NW 15-9N-22W, according to a newspaper announcement of Feb. 10, 1957. The outpost is on a unit block of 3,200 acres.
0.1	12.4	TRAFFIC LIGHT. PROCEED SLOWLY straight ahead.
0.8	13.2	Carter Consolidated School on south edge of town to right.
0.3	13.5	Dune sand derived from North Fork of Red River.
0.4	13.9	High-terrace sands and silts. Note Headquarters Mountain on horizon to southeast.
0.8	14.7	Turn left (east) on section line road, leaving Hwy. 34.
0.8	15.5	Whitehorse sandstone poorly exposed in ravine and roadcuts to right.
1.0	16.5	Turn right (south) on gravel road.
0.5	17.0	Dog Creek shale very poorly exposed in cultivated fields.
0.5	17.5	Road intersection (N one-quarter cor. 13-8N-22W). Continue ahead.
0.4	17.9	Unnamed gypsum member above Mangum dolomite at top of Blaine formation, exposed in roadcut on left.
0.4	18.3	Wire gate over cattle guard. Continue ahead.
0.05	18.35	Mangum dolomite capping Blaine escarpment at this locality is approximately 15 inches thick. The Mangum is oolitic dolomite which can be traced for

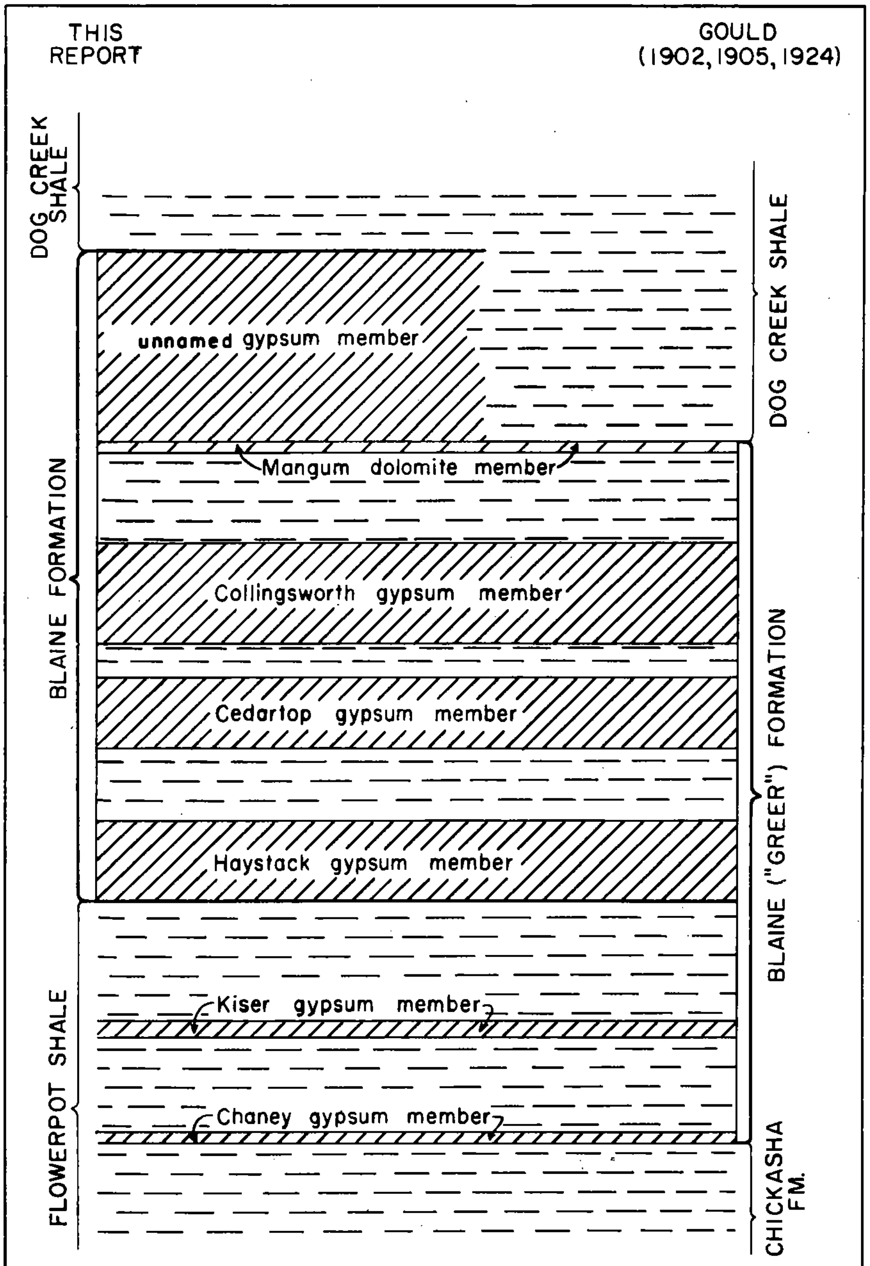


Figure 2. Classification of the Blaine formation in southwestern Oklahoma. Minor dolomite beds not shown.

Adapted from Oklahoma Geological Survey, Circular 42, 1957 (In press)

		hundreds of miles in southwestern Oklahoma. In earlier work, it was considered to be the top of the Blaine formation.
0.05	18.4	Turn left.
0.2	18.6	Outcrops of gypsum members and shale beds of Blaine formation in the dissected escarpment.
0.5	18.9	Park in pasture to right of road.

STOP 2. <u>Blaine formation and Flowerpot shale.</u>

NE one-quarter 24-8N-22W.

A magnificent view of the Blaine escarpment along North Fork of Red River is seen at this locality. Note also to the southeast, 12-20 miles away, the hills of Precambrian granite that form the westernmost part of the Wichita Mountains. At this distance the flat-topped wave-cut platforms on the granites may be plainly seen.

Members of the Blaine formation and of the underlying Flowerpot shale will be studied. Cut by North Fork and dissected by secondary streams flowing into it, the escarpment contains nearly complete exposures of 5 gypsum beds with associated dolomites and intervening shales.

Geology of the Carter area was studied by G. L. Scott, Jr. for a M. S. degree in 1955 at the University of Oklahoma. With certain changes it is to be published in 1957 as Circular 42 of the Oklahoma Geological Survey. One of the results of this work is that the older classification of the Blaine formation in southwestern Oklahoma is shown to be invalid. Original work by Gould published in 1902 and 1905 placed the top of the Blaine at the top of the Mangum dolomite and the base of the Blaine at the base of the Chaney gypsum. The new work has shown massive gypsum 40 feet thick immediately above the Mangum, which is thus logically associated with the "Blaine gypsum" and is so classified by the Oklahoma Geological Survey. Similarly, the thin Kiser and Chaney gypsum beds are excluded from the Blaine and placed in the upper part of the Flowerpot shale, as shown in Figure 2.

The following section at this locality, NE one-quarter 24-8N-22W, was measured by G. L. Scott, Jr. (measured section 6 of Figure 3.)

BLAINE FORMATION (partial section)	Feet
(Gypsum normally 35-40 feet thick is eroded from top of escarpment)	
<u>Mangum dolomite member:</u>	
Dolomite, gray-blue to brown, honeycombed, fine-to medium crystalline, oolitic in part, forms ledge and caps escarpment	2.0
Unnamed shale:	
Shale, red, partly covered	11.5
Shale, red, gypsiferous	3.0
Shale, red and green, containing several highly gypsiferous beds	3.0
<u>Collingsworth gypsum member:</u>	
Gypsum, white, massive, selentic in upper part, forms ledge. At base is finely crystal-	

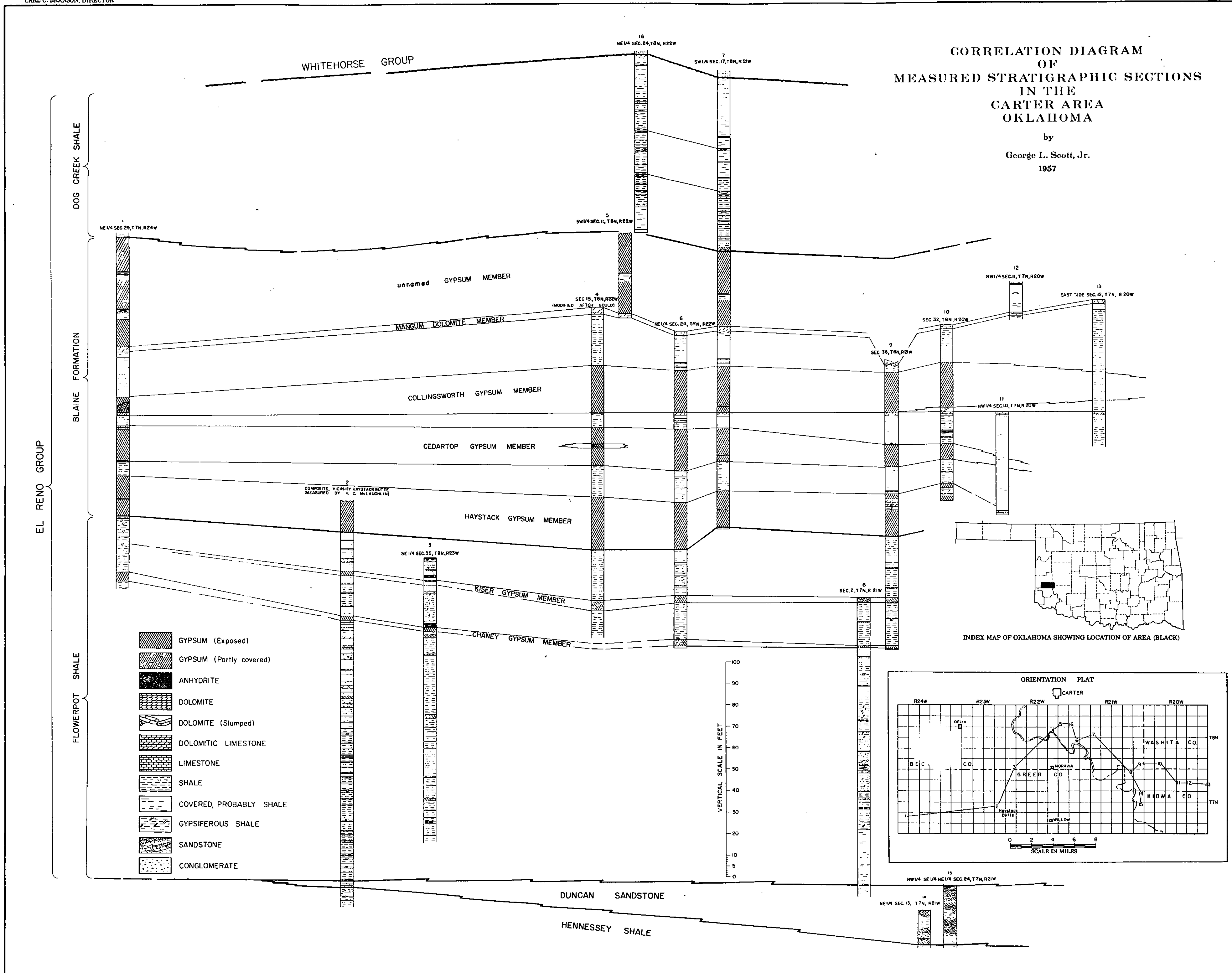


FIGURE 3. ADAPTED FROM OKLAHOMA GEOLOGICAL SURVEY, CIRCULAR 42, 1957 (IN PRESS)

LINE DOLOMITE 4 TO 6 INCHES THICK; AND A SIMILAR DOLOMITE OCCURS TWO AND ONE-HALF FEET ABOVE BASE -- 19.5

UNNAMED SHALE:

SHALE, GREEN -- 0.8

SHALE, ALTERNATING MAROON AND BLUE-GREEN LAYERS ABOUT 1 FOOT THICK ---------------------------------- 6.2

<u>CEDARTOP GYPSUM MEMBER:</u>

GYPSUM, WHITE, MASSIVE, MEDIUM-GRAINED IN PART, FORMS LEDGE. YELLOWISH BROWN DOLOMITE 2 INCHES THICK OCCURS AT BASE ----------------------------- 17.5

UNNAMED SHALE:

SHALE, GREEN WITH SMALL NODULES OF WHITE TO BROWN GYPSUM -- 1.5

SHALE, BRICK-RED -------------------------------------- 12.0

<u>HAYSTACK GYPSUM MEMBER:</u>

GYPSUM, WHITE, MASSIVE, COMPACT, FINELY CRYSTALLINE; LOWER FOOT IS DARK GRAY AND IS LOCALLY ARGILLACEOUS. CONTAINS 1-INCH DOLOMITE LAYER 7 FEET ABOVE BASE ------------------------------ 22.0

FLOWERPOT SHALE (PARTIAL SECTION)

SHALE, GREEN GYPSIFEROUS---------------------------------- 0.5

SHALE, PREDOMINANTLY RED, WITH THIN GREEN SHALE STREAKS AND NARROW SATIN SPAR VEINS--------------- 20.5

Kiser gypsum member:

Gypsum, white to light green and dark gray; finely laminated and shaly. Contains green shale streaks at base and near top	3.8
Shale, green	0.5
Shale, maroon and orange	16.0

Chaney gypsum member:

Gypsum, green to white, laminated to massive, containing green shale streaks	4.0
Shale green	0.8
Shale, maroon with thin green streaks	35.0
Shale, alternating red and green, in beds about 1 foot thick	6.0
Shale, green, with satin spar gypsum	2.0
Shale, red, with thin blue-green streaks and satin spar	3.5
Shale, blue-green	0.5
Shale, reddish brown	11.0

Covered to base of slope; total thickness of Flowerpot in this region is normally 165 feet.

On the bench of Cedartop gypsum at this stop a well of the Southeast Carter pool was spudded. Southeast Carter was a small nine-well pool which produced from granite wash of probable Lower Permian age in NE one-quarter 24-8N-22W and NW one-quarter 19-8N-21W at an average depth of

1,490 feet. It was discovered in January 1954 by Ward No. 1 Van Vacter, SW NW NW 19-8N-21W. Three wells produced 2,396 barrels of 39 degree gravity oil in 1955, and the cumulative production was 12,314 barrels. Oil accumulation is associated with stratigraphic traps modified by local structure and by the configuration of the Precambrian surface beneath the granite wash.

Three miles north, Carter No. 1 Taylor (C SW one-quarter SW one-quarter 30-9N-21W) penetrated Precambrian granite below Pennsylvanian arkose at 6,650 feet (-4790), Hunton at 7,610, Sylvan at 8,170, Viola at 8,210, Simpson at 8,790, and Viola at 9,130 feet, remaining in Viola to total depth of 10,499 feet. It is possible that several thrust blocks or some thrusting and an overturned fold in pre-Mississippian rocks were encountered. Beds in the Simpson dip at approximately 30 degrees, those in the lower part of the second Viola over 60 degrees.

About one and a half miles north-northwest of this Carter well, Northern Ordnance No. 1 Crawford (C NW SE 35-9N-22W, drilled in 1944) is reported to have passed from Pennsylvanian granite wash into Mississippian Sycamore at 7,900 (-6,000) Woodford at 8,080, total depth, 8,221 feet.

2.7	21.6	Return across cattle guard and continue north to end of road. Turn right (east).
0.5	22.1	Whitehorse sandstone exposed in roadcut.
4.0	26.1	Intersect state highway 55. Turn right (south).
0.4	26.5	Gypsum bed and red shales of Cloud Chief.
1.6	28.1	Turn left (east) on state highway 55.
2.0	30.1	RETROP -- SLOW DOWN.

WEST SENTINEL FIELD

To the north are rigs of the West Sentinel field, discovered by Gulf Oil Corporation with the completion of their No. 1 Dessie Hopkins (C NW SE 8-8N-20W) elevation 1,719 feet, on December 1, 1943. Oil zones were reported in granite wash of Pennsylvanian (Missourian?) age from 5,540 - 5,620 and 6,425 - 6,590 feet. On initial production well flowed 307 barrels oil, 40 barrels of water, and 88,200 cubic feet of gas in 24 hours. This well penetrated Arbuckle below Pennsylvanian granite wash at approximately 9,535 feet (possibly some Simpson above) and drilled to a total depth of 9,971 feet.

In 1955, 128,997 barrels of oil were produced from 19 wells, seven of which were drilled during the year. Cumulative production for the field at the end of 1955 was 810,822 barrels from a proved area of 760 acres. Production of oil or gas and distillate is obtained from porous zones in granite wash ranging in depth from 5,400 to 6,800 feet. Average gravity of the oil is 40 degrees.

3.0	33.1	Turn right (south) on gravel section line road.
0.5	33.6	Massive white gypsum exposed in ditch to right is near base of Cloud Chief formation.
0.25	33.85	Whitehorse sandstone.
0.75	34.6	Whitehorse sandstone.
1.4	36.0	Cross road. Enter Kiowa County, leave Beckham County.
1.6	36.2	Argillaceous silty dolomite exposure in lower part of DogCreek shale, in east roadcut.
1.1	37.3	Passing over outcrops of Blaine formation and Flowerpot shale, very poorly exposed in flat plains. Blaine escarpment is incon-

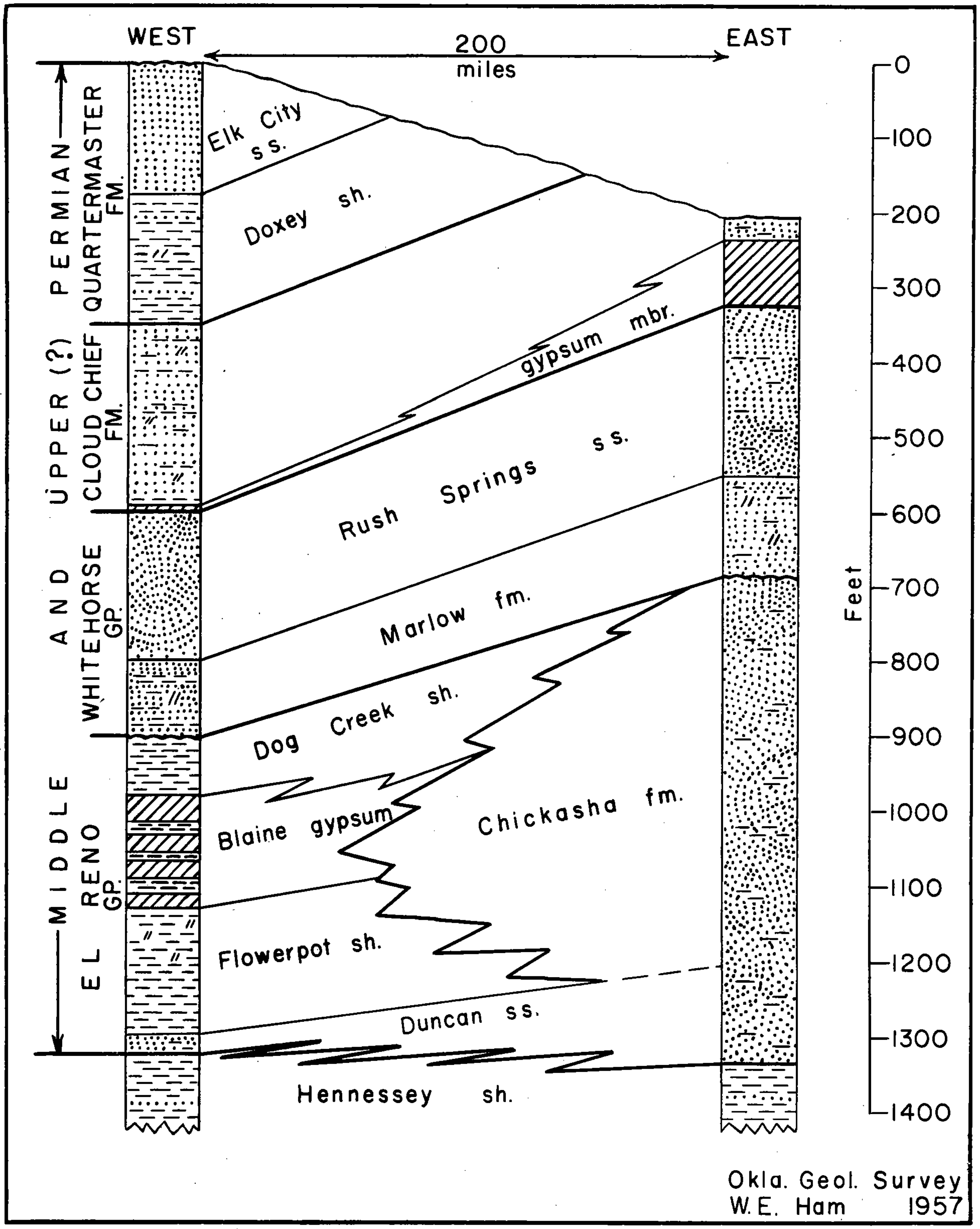


Figure 4. Classification and Principal Stratigraphic Relations of Middle and Upper (?) Permian rocks Cropping out on South Side of Anadarko Basin.

SPICUOUS EASTWARD FROM THIS AREA.

1.3 38.6 PARK ALONG RIGHT SIDE OF ROAD, KEEPING CARAVAN CLOSED UP.

STOP 3. DUNCAN SANDSTONE IN EAST ROADCUT.

NW ONE-QUARTER SW ONE-QUARTER 15-7N-20W.

DUNCAN SANDSTONE, TYPICAL OF THIS FORMATION IN SOUTHWESTERN OKLAHOMA, IS WELL EXPOSED IN ROADCUT. IT CONSISTS OF FINE-GRAINED THINLY BEDDED TO LOCALLY CROSS-LAMINATED SANDSTONE INTERBEDDED WITH GRAY-GREEN SHALE. ALTHOUGH REGIONAL DIP HERE IS 2 DEGREES - 3 DEGREES NORTHWARD TOWARD ANADARKO BASIN, THERE IS MUCH SLUMPING AND MANY DIP REVERSALS, AND SOUTHWARD DIPS AS HIGH AS 20 DEGREES MAY BE OBSERVED. THICKNESS OF THE DUNCAN IN THIS AREA IS 28 FEET, ONLY PART OF WHICH IS EXPOSED IN THE ROADCUT.

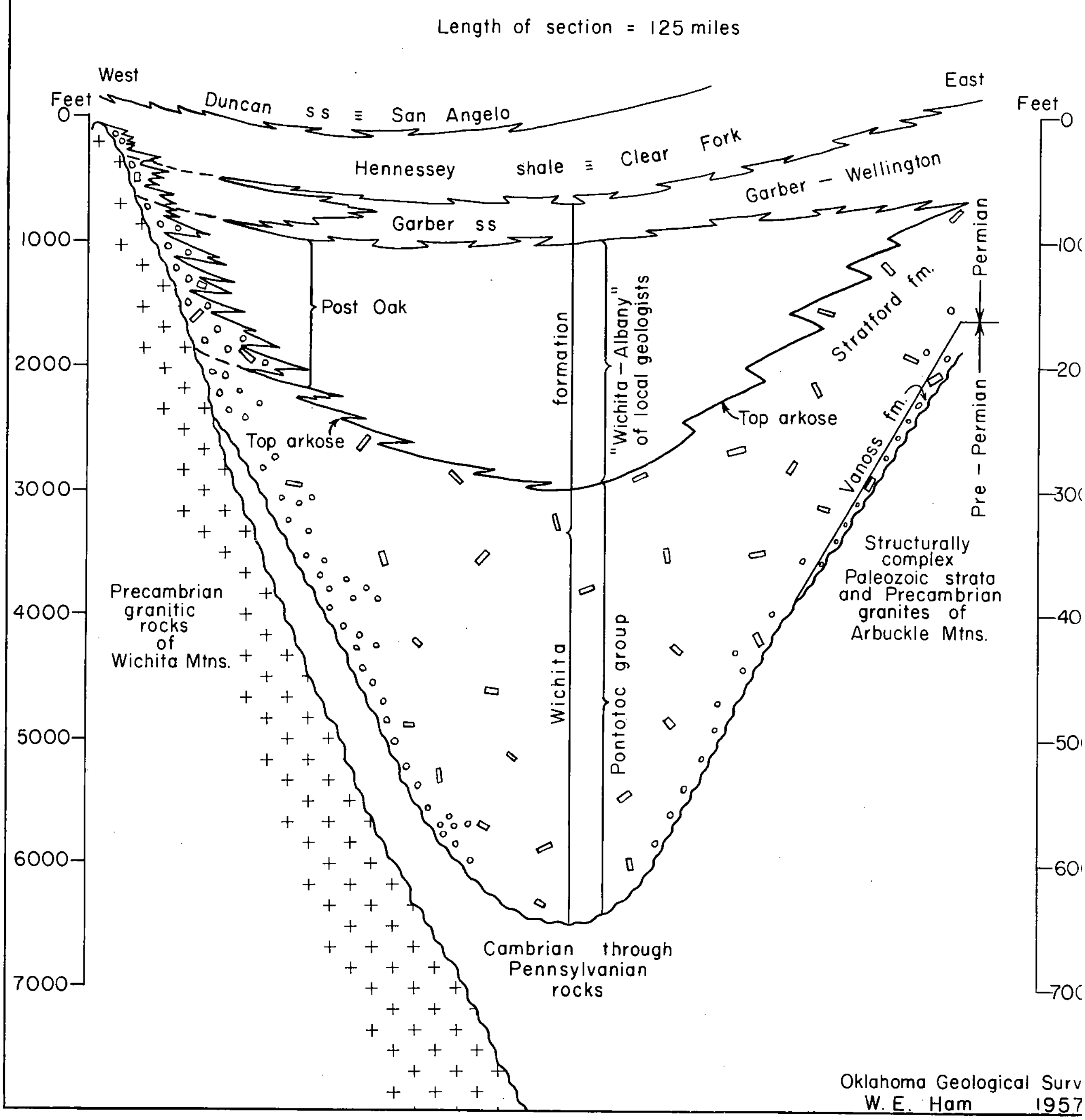
THE DUNCAN SANDSTONE IS THE BASAL FORMATION OF THE EL RENO GROUP, MIDDLE PERMIAN AND PROBABLY GUADALUPIAN IN AGE. IT CROPS OUT AS A LOW RIDGE WITH SOUTH-FACING ESCARPMENT THAT EXTENDS FROM THE VICINITY OF DUNCAN IN STEPHENS COUNTY NORTHWESTWARD TO THE CARTER AREA IN NORTHERN GREER COUNTY, WHERE THE SANDSTONE DISAPPEARS BY GRADATION INTO SHALE. SANDSTONE REAPPEARS IN NORTH TEXAS AT THE HORIZON OF THE SAN ANGELO, WITH WHICH THE DUNCAN IS CORRELATED.

BELOW THE DUNCAN SANDSTONE IN OKLAHOMA IS THE HENNESSEY SHALE. IT IS 300-600 FEET THICK AND EXTENDS FROM KANSAS THROUGH CENTRAL OKLAHOMA AROUND THE NORTH AND WESTERN SIDES OF THE WICHITA MOUNTAINS INTO TEXAS. ROCKS OF HENNESSEY AGE, PRINCIPALLY MAROON AND GREEN SHALE BUT CONTAINING ALSO SOME THIN SANDSTONES, COVER THE EXPOSED SIDES OF GRANITE HILLS IN THE WESTERN PART OF THE WICHITA MOUNTAINS NEAR QUARTZ MOUNTAIN, WHERE COARSE-CLASTIC ARKOSE AND CONGLOMERATES ARE LOCALLY PRESENT AS TONGUES WEDGING OUTWARD WITHIN THE SHALE.

Thus the mountains are known to have been at least partly exposed in Hennessey time, but they probably were entirely covered by late Hennessey deposits. The Duncan sandstone contains no mountain-derived coarse clastics, and presumably it extended over the buried mountains on a cover of Hennessey shale.

0.5	39.1	Turn right (west).
0.2	39.3	Contact of Duncan sandstone with underlying Hennessey shale, which crops out in broad shale plain westward and southward around Precambrian hills of granite in northwestern part of Wichita Mountains.
1.0	40.3	To the southwest is Flat Top Mountain, bordered on the west by Quartz Mountain and Headquarters Mountain. Flat Top Mountain's level top has been interpreted as a platform cut by waves on the floor of Permian seas.
2.2	42.5	Hennessey shale well exposed in bluff face to south and to lesser extent in road cuts. Here shale is mostly light gray-green, whereas in central Oklahoma Hennessey is mostly red.
0.1	42.6	Bridge over North Fork Red River. Enter Greer County, leave Kiowa County.
0.3	42.9	Curve left (south). NW cor. 24-7N-21W.
1.0	43.9	Alluvium on broad terrace of North Fork of Red River.
1.7	45.6	The low hill with the flat top is composed partly of Headquarters microgranite, which is oldest granite in Wichita Mountains.
3.1	48.7	The hill ahead on right is Headquarters Mountain, the eastern half of which is composed of Reformatory granite and the western part

Figure 5. Idealized section of Lower Permian rocks from Arbuckle Mountains through Anadarko basin to western edge of Wichita Mountains.



OF WHICH IS COMPOSED OF REFORMATORY GRANITE WITH ROOF PENDANTS OF HEADQUARTERS MICROGRANITE. THE SMALLER HILL TO THE NORTH-WEST IS ALSO A MIXTURE OF THESE TWO GRANITES. NOTE INTRICATE FRACTURING, JOINTING, AND MARKED EXFOLIATION.

0.1 48.8 GOOD EXPOSURES OF HENNESSEY FORMATION, MAROON AND GREEN SHALES TOGETHER WITH THIN SANDSTONE BEDS.

1.7 50.5 ENTERING THE TOWN OF GRANITE -- SLOW.

LAKE CREEK DISTRICT

THE FIRST ATTEMPTED OIL DEVELOPMENT IN THE VICINITY OF GRANITE WAS IN 1901 WHEN A LOCAL GROUP DRILLED A DRY TEST (NE ONE-QUARTER 35-10N-21W) TO A TOTAL DEPTH OF 380 FEET AND ENCOUNTERED GRANITE. DURING THAT SUMMER A LITTLE OIL WAS FOUND AT 168 FEET IN ANOTHER TEST (SE ONE-QUARTER NE ONE-QUARTER SEC. 10), NORTH OF HEADQUARTERS MOUNTAIN. A FEW OTHER TESTS WERE DRILLED AND A LITTLE OIL WAS FOUND, BUT NOTHING FURTHER WAS DONE IN THE REGION UNTIL 1904 WHEN A "DEEP" TEST WAS DRILLED IN THE WEST HALF OF NW ONE-QUARTER 24-7N-21W. THIS UNDERTAKING TOOK ABOUT THREE YEARS AND SEDIMENTARY ROCKS WERE PENETRATED TO 2,135 FEET WITH SHOWS OF OIL AND GAS REPORTED AT SEVERAL HORIZONS.

THE LAKE CREEK DISTRICT, WHICH IS REPORTED TO HAVE BEEN DISCOVERED IN 1945, CENTERS AROUND THE AREA OF THE SECOND TEST IN 10-10N-21W. THIS AREA WITH SOME 200 PROVED ACRES PRODUCES OIL WITH AN AVERAGE GRAVITY OF 36 DEGREES FROM 550 TO 750 FEET IN GRANITE WASH OF PROBABLE WICHITA (LOWER PERMIAN) AGE. CUMULATIVE PRODUCTION AT THE END OF 1955 FROM 20 WELLS, 10 OF WHICH WERE DRILLED THAT YEAR, WAS 32,369 BARRELS. ANNUAL PRODUCTION INCREASED FROM 2,948 BARRELS IN 1954 TO 23,008 BARRELS IN 1955.

0.1	50.6	Curve right (west) on main road.
0.2	50.8	Note wave-cut terrace low on hill behind second and third houses on right.
0.2	51.0	Abandoned quarry in Reformatory granite. Continue ahead (west).
0.5	51.5	Turn right to Pellow Brothers Monument Works. Reformatory granite which is being quarried here is the most coarsely crystalline of granites in this area.
0.1	51.6	Park cars in lot.

STOP 4. PELLOW BROTHERS MONUMENT WORKS. SE one-quarter NW one-quarter 26-6N-21W.

The rock quarried, cut, polished and engraved at this site is the Reformatory granite. This rock forms the eastern part of Headquarters Mountain (the hill northwest of Granite) and the western half of Quartz Mountain as well as the small hills between. The granite magma is believed to have been emplaced as a batholith.

The Reformatory granite is even-grained, coarsely crystalline, light pink in color and weathers to a deeper red. Many outcrops have small dark inclusions of gabbro or andesite and locally narrow aplite dikes cut the granite. These features may be observed in the quarry and in the polished blocks.

An average of eight thin sections of Reformatory granite gave the following mineralogical composition: microperthite and orthoclase, 65.8 per cent; quartz, 25.1; albite-oligoclase, 4.2; microcline, trace; hornblende 2.3; biotite, 0.6; aegirite-riebeckite, trace; and magnetite 0.2.

The chemical composition of the granite is:

SiO_2	74.14	Na_2O	4.61
Al_2O_3	12.97	K_2O	5.30
Fe_2O_3	1.07	H_2O at 110° C.	0.12
FeO	1.20	H_2O above 110° C.	0.19
MgO	Trace	TiO_2	0.25
CaO	0.48	MnO	0.03

The igneous rocks of the Lake Altus area are believed to be differentiates of a late Proterozoic magma. The age relationships of the rocks are given below:

Dikes (youngest).	There are four types: aplite, pegmatite, aegirine-riebeckite granite, and diabase.
Lugert granite.	Medium-grained red granite. It intrudes the Reformatory granite in the eastern part of Quartz Mountain.
Hornblende-biotite granite.	Medium-grained granite exposed only as small masses in the Little Bow-Powwow Mountains area in Sections 31 and 32, T. 5N. - R. 18W.
Reformatory granite.	Coarsely crystalline light pink granite.
Headquarters microgranite.	Fine-grained, brownish red granite. It is restricted to the western part of Headquarters Mountain and the small hills north of this locality. It occurs mainly

	As roof pendants and inclusions in the Reformatory granite.
Andesite.	Aphanitic black rock. Occurs as large dikes and sills in the eastern and central Wichitas and as xenoliths in the western part.
Gabbro-anorthosite (oldest)	The major exposures of these rocks are in the central and eastern parts of the Wichita Mountains. In the western Wichitas only small outcrops are known, but a magnetometer survey indicates a large subsurface band is present just west of Quartz Mountain.

0.15	51.75	Retrace route to road. Turn right.
0.5	52.25	Turn left (east) on state highway 9. ENTER HIGHWAY CAUTIOUSLY.
0.5	52.75	Railroad Crossing. CAUTION.
0.05	52.8	HIGHWAY INTERSECTION. CAUTION. Turn right (south) on state highway 6. Hill to east is type locality of Reformatory granite. State reformatory is located on the north edge of this hill. Large flat-top hill to southeast is Quartz Mountain. Note alluvial fan built up on west slope.
2.8	55.6	The small hills to the east are composed of Reformatory granite and are part of the Reformatory batholith that extends from the central part of Quartz Mountain.

Figure 6. Hennessey shale in normal development away from granite hills of the Wichita Mountains, exposed in badlands south of Elm Fork on east side of State Highway 6, NW SW 25-5N-21W. Sediments are interbedded maroon and gray-green shales containing, in lower part of exposure, thin concretionary beds of gypsum. Precambrian granite hills in background to east. Okla. Geol. Survey photo.

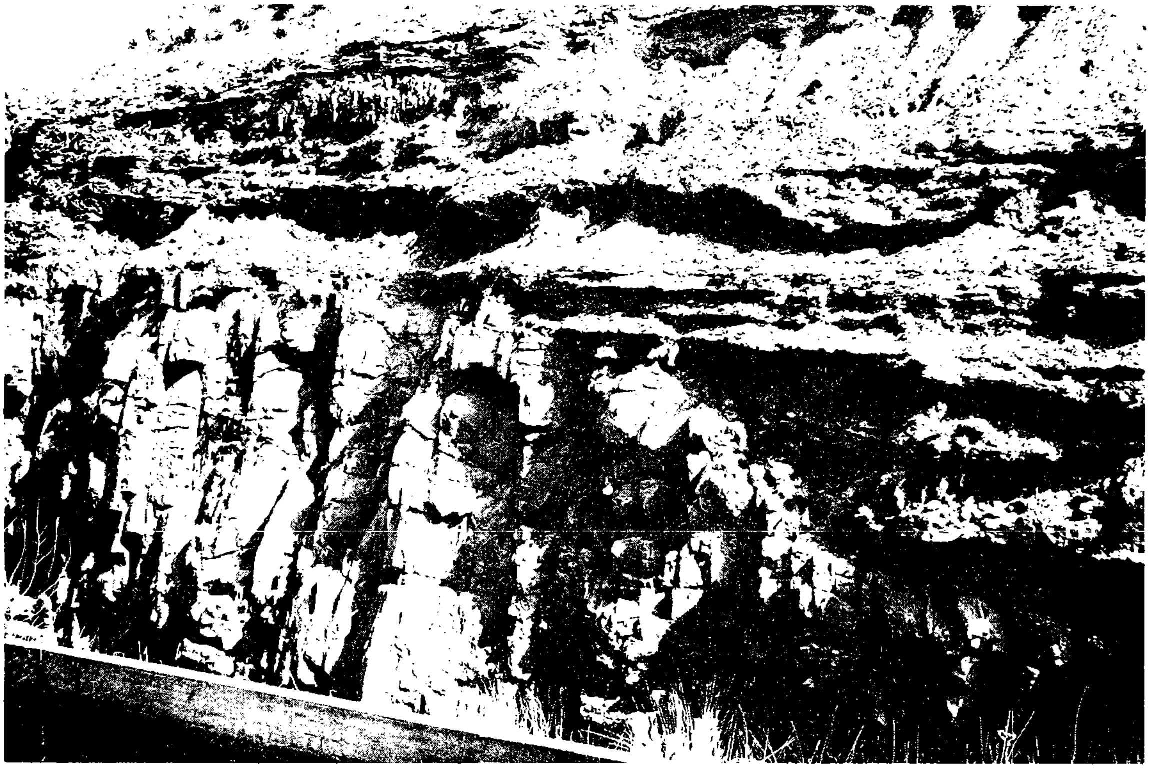


Figure 7. Strongly jointed Lugert granite unconformably overlain by near-shore facies of Hennessey shale, as exposed at STOP 5, cen. 33-5N-20W. Hennessey is overlapping the irregularly eroded granite surface and consists of maroon shale interstratified with beds of arkose and granite conglomerate. Coarse clastics disappear within short distance down dip to right of photo. Okla. Geol. Survey photo.

2.0	57.6	Bridge over Elm Fork of Red River.
0.7	58.3	Excellent exposures of banded gray-green and red Hennessey shale containing thin concretionary beds of gypsum.
1.5	59.8	JUNCTION WITH U. S. HIGHWAY 283. STOP - Turn east.
1.3	61.1	Low escarpment exposing variegated shales of Hennessey formation.
1.5	62.6	ATandSF RAILROAD CROSSING - CAUTION - JUNCTION WITH STATE HIGHWAY 44. Continue east on state highway 44.
0.05	62.65	Hill on right is Bird Mountain, which is composed of Lugert granite. Irrigation aqueduct runs along right of highway. Small abandoned quarry can be seen on base of hill.
0.85	63.5	Turn right on dirt road.
0.05	63.55	Follow right fork of road. Surrounding hills are composed of Lugert Granite.
0.25	63.8	Park Cars.

STOP 5. IRRIGATION CANAL CUT. NE one-quarter SW one-quarter SE one-quarter 33-5N-20W.

A vertical irrigation canal cut shows a large andesite xenolith surrounded by Lugert granite. A second feature of special interest is the erosional unconformity separating shales and conglomerate of Hennessey age from the underlying Precambrian granite.

The andesite inclusion is more than 50 feet wide and 30 feet thick and its length is unknown as it is not exposed at the surface except in the canal cut. It is surrounded by Lugert granite and is intruded by several fine-grained dikes and apophyses of the latter rock. A few small xenoliths, separated from the main andesite mass, also are present. The xenoliths are weathering to spheroidal masses.

The andesite is black and aphanitic, and in thin section it is seen to be highly altered, although a poorly defined diabasic texture is still noticeable. The major minerals are andesine, quartz, augite, hornblende, and biotite, and the minor constituents are magnetite, zircon, and apatite. Alteration of the feldspar and femic minerals has been intense and there is considerable chlorite, serpentine, and a small amount of hematite and clay. This alteration makes it impractical to determine the percentages of the primary materials. Most or all of the quartz has been introduced from the Lugert Magma and the basic rock is silicified andesite.

The erosional surface between Precambrian and Permian is clearly shown in the canal cut. The irregular eroded granite surface slopes to the west and is overlain by nearly horizontal layers of granite conglomerate and arkose interbedded with red shales of Hennessey age. The conglomerate sediments are composed of pebbles of igneous rocks, mainly granite in composition, and these grade westward downdip within a few feet into arkosic sands. This near-shore lithofacies of the Hennessey shale, Lower Permian in age, rests on Precambrian Lugert granite of probable late Proterozoic age.

0.3 64.1 Retrace route to state highway 44. Turn right (northeast).

0.1 64.2 Bridge over North Fork Red River. Enter Kiowa County, leave Greer County.

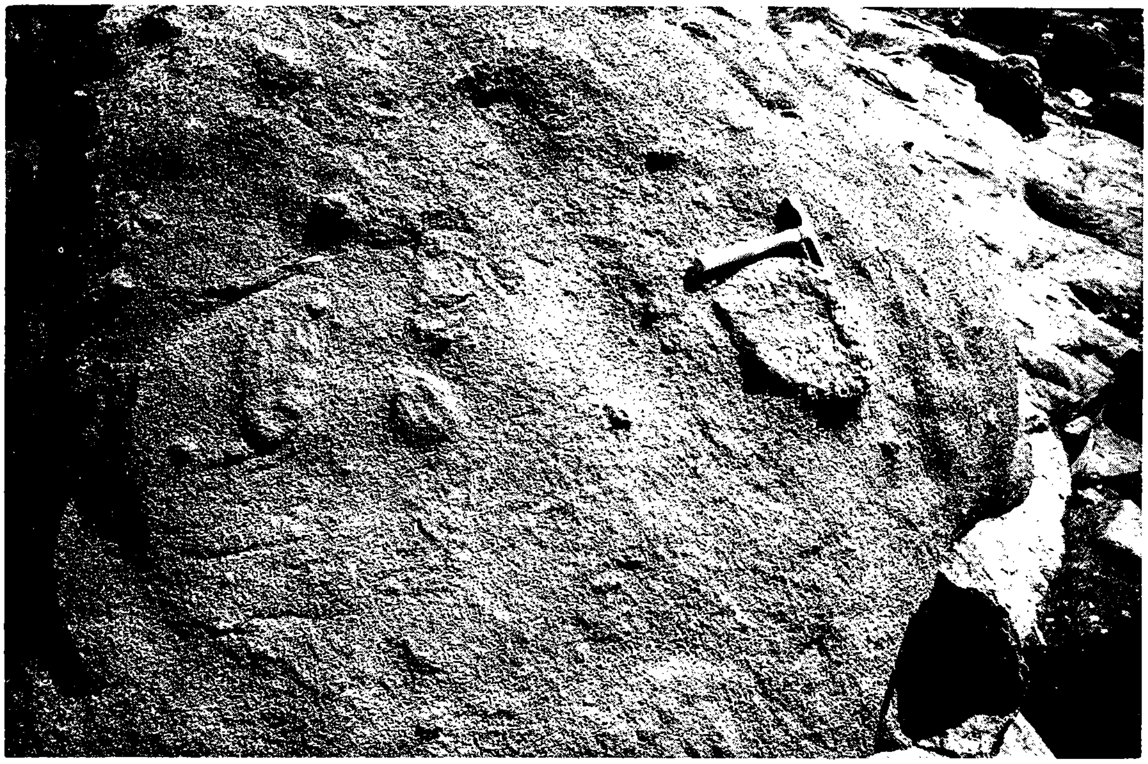


FIGURE 8. ROUNDED PEBBLE, COBBLE, AND BOULDER XENOLITHS INCORPORATED IN LUGERT GRANITE, AS SEEN AT STOP 6, NW NE NE 26-5N-20W. ZENOLITHS CONSIST OF GRANITE AND GRANITIZED SEDIMENTS DERIVED FROM A PRECAMBRIAN BOULDER CONGLOMERATE INTO WHICH THE LUGERT MAGMA WAS INTRUDED. OKLA. GEOL. SURVEY PHOTO.

0.65	64.85	Entrance to Quartz Mountain State Park on left. Continue ahead on Highway 44.
0.9	65.75	Road cut in Lugert granite.
1.35	67.1	Turn right (east) on gravel road.
0.25	67.35	Park cars along road.

STOP 6. Pebble xenoliths in Lugert granite, NE one-quarter NE one-quarter 26-5N-20W

This outcrop of Lugert granite contains many inclusions which stand out in relief on the weathered surface. The xenoliths are interpreted as pebbles and cobbles derived from a Precambrian granite conglomerate into which the Lugert magma was intruded. The inclusions are mainly granite aplite but some are muscovite-biotite granite, microgranite porphyry, granite porphyry, arkose, gabbro, and basalt porphyry. One pebble is an aggregate of angular grains of quartz with a cement of fine-grained quartz and perthite. In most of the inclusions some hornblende has been introduced along the contact with the Lugert granite but otherwise no significant alteration is apparent.

The original cement of the conglomerate, clay or other material, apparently has been completely assimilated. In shape the xenoliths are variable, some being sub-angular, many elliptical and a few rounded. They range from an inch to four feet in length but most are a few inches in diameter.

The inclusions are horizontal and show a crude orientation averaging N67° W. About a mile south in NW one-quarter NW one-quarter SE one-quarter SW one-quarter 25-20N-20W the inclusions also are horizontal and trend N70° W. The orientation is believed to result from magmatic flowage.

The presence of several types of igneous rocks in the pebbles indicates that an older igneous complex was eroded to furnish the granite conglomerate. There are no known exposures of this older complex in the area.

The only outcrop of Precambrian sediments in the Wichita Mountains is the Meers quartzite which occurs as a roof pendant in gabbro. This quartzite is considered to be the oldest rock in Oklahoma. Its relationship to the granite conglomerate intruded by the Lugert granite in the Lake Altus area is not established, but the relatively pure quartz sandstone which formed the Meers quartzite was deposited in a different sedimentary environment from that of the granite conglomerate, though the latter may have been a local facies or part of the sedimentary series. There are some indications that old sediments once were widespread in the Wichita Mountains. In the Cold Springs area south of Roosevelt, sillimanite and spinel occur in minute amounts in anorthosite and may indicate assimilation of clayey sediments by a basic magma. Rounded zircon and tourmaline grains were noticed in a few thin sections of Reformatory granite from the hills near Granite. These minerals may be relic detrital grains of old sediments.

0.15	67.50	Continue ahead to Lugert Church. Make U-turn and retrace route to highway.
0.45	67.95	Turn left (southwest) on state highway 44.
2.25	70.2	Entrance to Quartz Mountain State Park. Turn right (north) and continue on road to Lodge.
3.6	73.8	Quartz Mountain Lodge.

END OF FIRST DAY

ROAD LOG FOR FRIDAY, MAY 3

Caravan assembles at Quartz Mountain Lodge, leaving at 8:00 A.M.

0.0	0.0	Granite in surrounding hills is Lugert granite, completely jointed and strongly exfoliated. Eastward across Lake Altus is Dome Mountain, the top of which represents a Permian wave-cut terrace.
0.3	0.3	Roadcut exposing coarse granite conglomerate interstratified with red and green shale of Hennessey formation. Note also, at north edge of cut, the lens of highly felspathic arkose. Compare the abundance of coarse clastics in this locality with the relative scarcity of coarse conglomerate in the same formation at STOP 5 (May 2), where the shales were evidently deposited on a protected side of the granite hills which was receiving little debris.
0.1	0.4	Andesite inclusions in Lugert granite in roadcut to right.
0.6	1.0	Roadcut exposing rocks of Hennessey formation, here composed predominantely of arkose interbedded with thin gray-green and red shale. Note boulders as much as four feet in diameter which evidently dropped into Hennessey sea from hill behind.
1.0	2.0	Lugert granite exposed in hills to right with Reformatory granite in hill ahead. Note irregular contact between Lugert and Reformatory granite, difficult to see except under optimum lighting conditions.

0.15	2.15	Bridge over North Fork Red River. Look downstream to excellent exposure of maroon and green shale of Hennessey formation in stream bank. Observe nearly horizontal dip.
1.4	3.55	ATandSF RAILROAD CROSSING - CAUTION Directly ahead, low on the face of King Mountain, are many Permian wave-cut grooves in Lugert granite.
0.05	3.6	CAUTION. Enter State Highway 44, turning left(northeast).
0.9	4.5	Roadcut outcrop of Lugert granite cut by dike of diabase showing pinch-and-swell structure.
0.2	4.7	Coarse and fine granite wash of Hennessey age in roadcut to right.
1.7	6.4	Town of Lugert. At beginning of 20th century, Lugert was a town of several hundred miners and prospectors.
0.3	6.7	Turn right (east) on gravel road, leaving state highway 44.
0.8	7.5	Riding along plain of Hennessey shale. At right is Flat Top Mountain, so named for its flat surface thought to be cut as a submarine bench in Permian seas.
2.3	9.8	Tepee Baptist Church on right. Highest hill to southeast, 1.5 miles away, is Mt. Tepee.
2.0	11.8	Denny's Grocery and Filling Station at cross roads.
1.3	13.1	Road curves around hill of Lugert granite. Back of red-roofed dwelling is large boulder pile of type that form boulder streams. The sedimentary rocks around this hill dip at a low angle westward. Although the contact is not

Figure 9. Near-shore facies of Hennessey shale exposed in roadcut on highway 0.3 miles south of Quartz Mountain Lodge, SW SW 15-5N-20W. Maroon and gray-green shales are interstratified with prominent beds of granite cobble-boulder conglomerate and arkose derived from Lugert granite that crops out in backbround. Okla. Geol. Survey photo.

FIGURE 10. BEACH GROOVES OR FLUTINGS CUT ON LUGERT GRANITE BY LOWER PERMIAN SEA AS SEEN AT STOP 1, NE NW 7-5N-18W. GRANITE IN FOREGROUND HAS JUST BEEN EXHUMED BY EROSION OF SHALES IN WICHITA FORMATION, WHICH AT THIS LOCALITY CONTAIN NO CONGLOMERATES. SIMILAR MARKINGS ARE VISIBLE AT BASE OF HILL IN BACKGROUND BUT HAVE BEEN DESTROYED BY WEATHERING AT HIGHER ELEVATIONS ON THE HILL. OKLAHOMA GEOL. SURVEY PHOTO.

EXPOSED, THE BOUNDARY BETWEEN HENNESSEY SHALE AND THE UNDERLYING WICHITA FORMATION IS AT THIS LOCALITY.

1.8	14.9	TURN LEFT (NORTH).
1.0	15.9	TURN RIGHT (EAST)
0.1	16.0	JOG LEFT (NORTH).
0.5	16.5	IN BADLAND ESCARPMENTS TO EAST AND WEST ARE EXCELLENT EXPOSURES OF RED AND GRAY-GREEN SHALE IN UPPER PART OF WICHITA FORMATION.
0.5	17.0	TURN LEFT THROUGH IRON GATE ONTO PRIVATE ROAD.
0.6	17.6	PARK IN PASTURE ON RIGHT.

STOP 1. POTHOLES AND WAVE-CUT GROOVES IN GRANITE BEING EXHUMED BY EROSION OF WICHITA SHALES. NE ONE-QUARTER NW ONE-QUARTER 7-5N-18W.

POTHOLES AND WAVE-CUT GROOVES IN THE LUGERT GRANITE ARE EXCEPTIONALLY WELL DEVELOPED IN THIS LOCALITY. THE POTHOLES ARE SHALLOW, CIRCULAR DEPRESSIONS A FEW FEET IN DIAMETER, WHICH WERE FORMED BY THE EDDYING OF STONES ON THE GRANITE FLOOR OF THE WICHITA SEA.

HORIZONTAL GROOVES AN INCH TO A FEW INCHES IN DEPTH MAY BE SEEN ON THE VERTICAL FACES OF THE LUGERT GRANITE WHERE THE PERMIAN SHALES ARE BEING ERODED AWAY. THESE GROOVES ARE FOUND IN SEVERAL PLACES IN THE WESTERN PART OF THE WICHITA MOUNTAINS, THE LARGEST SURFACE SHOWING THESE FLUTINGS BEING IN THE SW ONE-QUARTER 33-5N-20W, WHERE SOME MAY BE TRACED HORIZONTALLY FOR 375 FEET AND THROUGH A VERTICAL RANGE OF 90 FEET. THEIR ORIGINAL VERTICAL RANGE IS NOT KNOWN AS THE UPPER ONES HAVE BEEN DESTROYED AND THE LOWER ONES ARE NOW BEING uncovered by the erosion of the Permian shales.

The grooves were formed by the action of the waves of the Permian seas (Wichita and Hennessey) on the granite islands and shores. On the top or flanks of some of the granite hills of the Lugert area are flat surfaces normally 50 to 300 feet wide, which are believed to be remnants of Permian wave-cut platforms.

The wave-cut grooves show that the present igneous outcrops in the western part of the Wichita Mountains resemble in shape and size the granite islands in the Permian sea. Erosion, however, has lowered the peaks somewhat and the lower flanks of the hills are still covered by shale layers. In Permian times this area was an archipelago.

0.6	18.2	Retrace route to gate.
1.05	19.25	Jog right (west) then left (south) and continue ahead toward Camelback Mountain.
1.55	20.8	Century Granite Company quarry, in Lugert granite on northwest side of Camelback Mountain. Stone from this quarry, opened in 1950, is trucked to the company finishing plant at Snyder.
0.1	20.9	Grooves and potholes in Lugert granite.
0.1	21.0	Note Indian petroglyphs in rock to left.
1.3	22.3	In badlands escarpment to left and right are variegated shales of Wichita formation.
1.0	23.3	Begin winding road around Pow Wow Mountain. On east point of hill is dark-colored gabbro, in part thoroughly decomposed by

HYDROTHERMAL ACTION. ROADCUT EXPOSURES SHOW THIN CROSS-CUTTING DIKES OF PINK, FINE-GRAINED GRANITE.

0.2 23.5 TURN LEFT (EAST).

0.3 23.8 TURN RIGHT (SOUTH).

1.0 24.8 TURN RIGHT (WEST).

1.05 25.85 PARK CARS AS INSTRUCTED BY FLAGMEN.

STOP 2. TEPEE CREEK SEDIMENTS AT TYPE LOCALITY. SW ONE-QUARTER SW ONE-QUARTER 6-4N-18W.

THE TEPEE CREEK SEDIMENTS, DISCOVERED AND NAMED BY MERRITT AND HAM (BULL. AMER. ASSOC. PETROLEUM GEOL., VOL. 25, 1941, P. 287-299), ARE A UNIQUE SEQUENCE OF ROCKS. ORIGINALLY A FINE-GRAINED CONGLOMERATE MADE UP CHIEFLY OF PEBBLES AND SAND-SIZED GRAINS OF ANORTHOSITE, WITH WHICH A FEW BEDS OF DOLOMITE ARE INTERSTRATIFIED, THE ROCK NOW CONSISTS PRINCIPALLY OF ZEOLITES AND OPAL. THE NEW CONSTITUENTS ARE INTERPRETED AS FORMING DIAGENETICALLY THROUGH THE ACTION OF MARINE WATERS ON THE ANORTHOSITE CONGLOMERATE. ROCKS OF THIS COMPOSITION AND ORIGIN HAVE NOT BEEN DESCRIBED FROM ANY OTHER AREA IN THE WORLD.

STRATA OF THE TEPEE CREEK ARE NEARLY FLAT-LYING. HERE AT THE TYPE LOCALITY THE MAXIMUM THICKNESS OF 47 FEET WAS MEASURED, BUT SINCE THE BASE IS COVERED AND THE TOP IS ERODED ITS FULL THICKNESS IS UNKNOWN. THE STRATA REST WITH PRONOUNCED ONLAPPING UNCONFORMITY ON THE SLOPING SIDES OF THE PRECAMBRIAN ANORTHOSITE HILL. HIGH IN THE EXPOSED SECTION, ABOVE THE OLD PROSPECT TRENCH, THE SEDIMENTS ARE PRESERVED ONLY AS SCATTERED REMNANTS SEPARATED BY WIDE OUTCROPS OF GRAY ANORTHOSITE.

TYPICALLY DULL BRICK RED BUT RANGING THROUGH PURPLISH AND GRAY, THE ROCK is composed of a variable mixture of natrolite, opal, dolomite, and residual slightly altered fragments of labradorite feldspar derived from the anorthsite. The lower of the two beds near the top of the west wall of the trench has been analyzed and found to contain 60.1 percent zeolites, 22.3 percent dolomite, and 11.6 percent opal. In this bed practically no pebbles of the original basic igneous rock remain, the rest having been altered to the constituents listed above. Eastward from the type locality, as for example in the NE one-quarter SE one-quarter 26-4N-17W, outcrops of the Tepee Creek are lacking in dolomite and are much less altered, containing 52 percent zeolites, 1.8 percent calcite, and 46.2 percent unaltered anorthosite fragments plus opal.

These sedimentary rocks are exceptional because they were originally made up of fragments of a labradorite-rich plutonic rock, a comparatively rare rock type, and also because of the peculiar alteration that converted these materials on the sea floor to zeolites and opal. A similar rock would not be derived from alteration of the widely distributed arkoses that result from the weathering of granites.

The Tepee Creek was originally assigned a Precambrian age, based on the assumption that the massive zeolite-bearing rocks exposed at the tunnel on the west side of the hill are equivalent to the layered rocks of similar composition on the south side. At the tunnel the anorthosite and zeolitic rock are cut by an aplite dike known to be Precambrian, from which it was clear that the zeolitic rock, being older than the dike, also was of Precambrian age. It is now believed, partly through the work of Mayes (unpublished M. S.

thesis, University of Oklahoma, 1947), that the zeolitic rock cut by the dike is anorthosite altered hydrothermally in place, and therefore is not related in age to the layered, pebble-containing zeolite rock on the south side of the hill which obviously is a post-anorthosite sediment. It is indeed a remarkable coincidence that two petrologically similar rare rocks, with such an enormous difference in mode of origin and in age, would happen to be found less than 100 yards apart!

As now used, the term Tepee Creek is applied to the zeolite-opal sediments that were deposited as anorthosite conglomerates and sandstones unconformably on the basic igneous rocks in the central part of the Wichita Mountain region. Their age can no longer be accepted as Precambrian. Instead, these sediments probably are the coarse-clastic shoreward facies of shales in the Wichita formation of lower Permian age. Also included in this general classification are the limestone conglomerates, granite conglomerates, and arkoses which in the eastern part of the Wichita Mountains are called Post Oak and are classed as a member of the Wichita formation (Chase, G.W., Bull. Amer. Assoc. Petroleum Geol., vol. 38, 1954, p. 2028-2035).

The general concept of the Post Oak member must now be revised, however, to take into consideration rather extensive granite conglomerates and arkoses in the overlying Hennessey formation that border granite hills in the Quartz Mountain area near Lugert.

1.05	26.9	Retrace route 1 mile east to gravel road. Turn right (south).
0.7	27.6	SLOW - Curve right, then left over one-way bridge.
0.3	27.9	Turn left (east). Ahead to right are trench silos cut in shales

		of Wichita formation.
2.5	30.4	Cultivated plains are extensively used for wheat growing.
1.5	31.9	Turn right (south).
0.5	32.4	Shallow road cut exposures of hydrothermally altered anorthosite.
0.5	32.9	Turn left (east).
1.0	33.9	Turn left (north). Follow winding road around west side of Round Mountain.
0.4	34.3	Turn right (east)through wire gate.
0.25	34.55	Park in pasture to left of road.

STOP 3. <u>Abandoned quarry in Cold Springs granite, north face of Round Mountain NW one-quarter SW one-quarter 18-4N-17W.</u>

This quarry, known as the Roosevelt, shows the relationship of andesite and Cold Springs granite.

A layer of andesite a few feet thick is present at the top of the quarry. This basic rock is part of a widespread sill which is exposed at various places in the Cold Springs area to the southeast. The andesite has been intruded by a granite and the former was broken into fragments which have been assimilated and changed to a gray granitic-like rock known as the Cold Springs "granite". Faint outlines of the assimilated inclusions (shadow inclusions) may be seen in the granite blocks and in the quarry face.

Thin sections of the Cold Springs "granite" shows both olgoiclase (Ab 72) and andesine (Ab 53), the latter being a relict mineral from the assimilated andesite. The rock ranges in composition from a hornblende granite through quartz monzonite and granodiorite to a quartz diorite. It is a hybrid rock and its composition depends upon the amount and degree of assimilation of andesite. A thin section from the quarry gave the following mineral percentages: orthoclase 36.2, Plagioclase 25.2, quartz 19.9, hornblende 9.2, biotite 6.2, pyroxene 0.8, magnetite 1.7, and traces of apatite, zircon and pyrite.

0.2	34.75	Retrace route back to wire gate. Turn right (north) back onto gravel road.
1.6	36.35	Anorthosite poorly exposed in small hill west of road.
0.5	36.85	Turn right (east).
0.65	37.5	RAILROAD CROSSING, Frisco RR. THREE TRACKS. CAUTION. Roosevelt Depot. Enter Roosevelt.
0.2	37.7	Intersect U.S. Highway 183. Turn left (north) through Roosevelt.
0.5	38.2	Junction Oklahoma State Highway 19. Turn right (east) toward Cooperton.
0.9	39.1	Curve around south edge of low anorthosite hill. Passing through western portion of Raggedy Mountains, the central chain of hills in the Wichita Mountains, which are composed mainly of anorthosite. This is one of the largest areas of anorthosite in the United States, other large areas being in Wyoming and New York.
0.8	39.9	Hills to north, some of which show wave-cut platforms, are composed of Cooperton granite.
7.0	46.9	Hills ahead are composed of granite that in the past has been

		described as Lugert but which may not be equivalent to Lugert granite of the Quartz Mountain area.
0.3	47.2	Junction, State Highway 54. STOP. Turn left (north).
0.7	47.9	Cooperton. Continue straight ahead.
1.6	49.5	Hill ahead on right is Unap Mountain, made up of Arbuckle limestone, at northwestern end of the Limestone Hills. Quarry on south face is that of Roosevelt Materials Company in Kindblade limestone, middle Lower Ordovician in age. The stone from this quarry is crushed and extensively used as road-building aggregate. Kindblade limestone is equivalent to Honeycut formation of Ellenburger group in Texas.
3.4	52.9	Roadcuts exposing maroon shale of Wichita formation.
1.3	54.2	Wichita formation in roadcuts.
0.9	55.1	Wichita formation in roadcuts.
0.1	55.2	Turn right (east) on gravel road, leaving Hwy. 54.
0.15	55.35	Lone hill to north is Rainy Mountain, which contains outcrops of shale in the Bromide formation on south face and Viola limestone at top and on north slope. The strata dip approximately 20° northeastward. These are the youngest older Paleozoic rocks exposed in the Wichita Mountain region. They crop out in the axial part of the Rainy Mountain syncline.
2.85	58.2	Turn left (north).
0.55	58.75	Turn right off section line road onto quarry road.
0.35	59.1	Park cars at quarry.

STOP 4. Viola limestone, NE one-quarter SW one-quarter 20-6N-15W.

Otis quarry of Gilbert Contracting Company, operated as a source of crushed stone beginning July, 1956, for use in airfield construction at Burns Flat Air Base near Clinton.

Probably the most widely distributed and most easily recognizable rock unit in Oklahoma is the Viola limestone, of Middle Ordovician (Trenton and slightly older) age. Because it is overlain by the distinctive Sylvan shale and underlain by the shale-limestone-dolomite-sandstone sequence of the Simpson group, the Viola makes an excellent datum for seismic shooting. It also is an important top called in subsurface geology, partly because of its persistence and partly for its position just above the oil-rich Simpson sands - Bromide, Tulip Creek, McLish, and Oil Creek. One or more of these sands is locally called Wilcox.

Maximum thickness of the Viola on the outcrop is in the western part of the Arbuckle Mountains and in the Criner Hills, where it is 900 feet thick. The Viola limestone proper, or "Trenton Viola", at many places is overlain by as much as 100 feet of coarse-grained nearly pure limestone called "Fernvale", but the two normally are combined under the general term Viola. Both produce oil in some pools. The Viola of Oklahoma probably is equivalent to the Montoya limestone of the El Paso region in Texas.

The hill at this stop is one of four outcrops of Viola limestone on the folded northeast flank of the Wichita Mountains. The rocks dip 15-20° northeastward, defining the south limb of the Rainy Mountain syncline, and they are

THE YOUNGEST OF THE OLDER PALEOZOIC ROCKS EXPOSED IN THE REGION. THE VIOLA HILLS ARE SURROUNDED BY NEARLY FLAT-LYING SHALES OF THE WICHITA FORMATION, ABOVE WHICH THEY STOOD AS A CHAIN OF ISLANDS IN EARLY PERMIAN TIME. MAROON SHALE CONTAINING LENSES OF LIMESTONE CONGLOMERATE DERIVED FROM THE VIOLA LOCALLY OCCURS LOW ON THE SLOPES OF THE HILLS.

EXPOSED IN THE QUARRY ARE BEDS IN THE LOWER PART OF THE VIOLA LIMESTONE. THEY CONSIST OF HIGHLY CHERTY, WELL-BEDDED LAYERS CONTAINING GRAPTOLITES (*DIPLOGRAPTUS*, *CLIMACOGRAPTUS*, AND OTHERS) AND OCCASIONALLY A WELL-PRESERVED SPECIMEN OF THE LACE-COLLAR TRILOBITE *CRYPTOLITHOIDES*. IN THE HILL ITSELF ABOUT 350 FEET OF VIOLA CROPS OUT. NEARLY 250 FEET IS COVERED BY SHALE BEYOND THE NORTH FLANK, THE THICKNESS OF THE VIOLA IN THIS AREA BEING ABOUT 575 FEET.

BENEATH THE VIOLA IN THE SOUTH-FACING ESCARPMENT ARE SHALES, SANDSTONES, AND LIMESTONES IN THE UPPER PART OF THE BROMIDE FORMATION, THE HIGHEST AND ONLY GOOD OUTCROPS OF ROCKS IN THE SIMPSON GROUP OF THE WICHITA MOUNTAIN REGION. TO DR. C. E. DECKER (OKLA. GEOL. SURV. BULL. 55, 1931, P. 86) WE ARE INDEBTED FOR THE FOLLOWING SECTION MEASURED AT THIS LOCALITY:

VIOLA LIMESTONE.

BROMIDE FORMATION

	FEET
GREEN SHALE INTERBEDDED WITH THIN SANDY DOLOMITIC LIMESTONE, ONLY PARTLY EXPOSED IN EXCAVATIONS BELOW QUARRY -----------	25.0
GRAYISH BROWN MEDIUM-GRAINED ARGILLACEOUS LIMESTONE ----------	2.5
SHALE AT TOP TWO FEET UNDERLAIN BY YELLOWISH PINK LIMESTONE, OLIVE-GREEN PLATY SHALES AT BASE -------------------------	13.0

Sandstone, porous, white and yellowish, rather well indurated- 5.0

Shale, bright olive-green. Only partly exposed ----------- 20.0

Limestone, buff, iron-stained ----------------------------- 3.0

Sandstone, gray to buff and pink, coarse grained, well indurated -- 18.8

Covered by shale to base of hill.

LUNCH STOP

Return to cars for box lunch, being careful to put all refuse into containers provided for this purpose.

0.35	59.45	Retrace route to road. Turn left (south).
0.55	60.0	Turn left (east).
1.0	61.0	Cattle guard. Continue east.
0.15	61.15	Curve around south slope of hill containing shale of Bromide formation capped by Viola limestone.
0.9	62.05	Turn right (south) at intersection (NE cor. 8-6N-15W).
1.0	63.05	Turn left (east).
0.45	63.5	Flat plains are underlain by shales of Wichita formation. Longhorn Mountain one and one-half miles to south is prominent in the Limestone Hills that border the northeast flank of the Wichita Mountains. These hills are made up mostly of Arbuckle limestone, locally containing outcrops of Reagan sandstone and Honey Creek limestone of the Timbered Hills group just above the granite.
2.55	66.05	Intersection with paved road. Continue ahead (east).

1.0	67.05	Road intersection. Continue ahead (east) on gravel road. NW cor. 32-6N-14W.
1.0	68.05	Road intersection. Pecan School on left.
0.6	68.65	Hill ahead is Bally Mountain, made of intensely shattered Carlton rhyolite porphyry.
0.45	69.1	Turn right (south). NE cor. 33-6N-14W.
1.0	70.1	Turn left (east). Immediately to south is unnamed hill composed of Arbuckle limestone. Rocks dip southwest, on flank of Blue Creek Canyon anticline. Ahead on left, across valley of igneous rocks covered with thin Wichita shale, is an impressive line of hills in which Timbered Hills and Arbuckle strata dip northeast on opposite side of anticline. At north end of these hills are best and most complete exposures of Cambrian and Lower Ordovician rocks in Wichita Mountain area.
3.0	73.1	Enter Caddo County, leave Kiowa County.
0.8	73.9	Excellent exposure of maroon and gray-green shales of Wichita formation on right of road.
0.2	74.1	Turn right (south) on state highway 58. Roadcuts containing excellent exposures of maroon and gray-green Wichita shales with some calcareous concretions. Limestone gravel of Quaternary age covers the outcrops.
3.0	77.1	CAUTION. Continue straight ahead on gravel road, leaving state highway 58.

1.0	78.1	Turn left (east).
0.5	78.6	Post Oak conglomerate, a coarse-clastic facies of Wichita formation, exposed in roadcut and ravine to right.
2.5	81.1	Turn right (south). Arbuckle limestone in low hill to east.
1.0	82.1	Cattle guard.
1.1	83.2	Enter Comanche County, leave Caddo County. Entering Blue Creek Canyon. Limestone conglomerate facies of Post Oak exposed in roadcut.
0.3	83.5	Park as close to shoulder of road as possible and pull up close to car ahead.

STOP 5. Post Oak conglomerate member of Wichita formation.

SW one-quarter 35-5N-13W.

The conglomerates of lower Permian age in and around the eastern two-thirds of the Wichita Mountains have been termed the Post Oak conglomerate by Chase (1954, Permian conglomerate around Wichita Mountains, Oklahoma: Bull. AAPG, vol. 38 no. 9). Chase noted four facies of this conglomerate (1) Granite boulder conglomerate; (2) Rhyolite porphyry conglomerate (3) Conglomerate with zeolite-opal cement (Tepee Creek); and (4) Limestone boulder conglomerate.

The cobbles of the limestone boulder conglomerate which are visible at this stop were derived from the Arbuckle limestone in the closely adjacent limestone hills. At this locality some evidence of shaly material more typical of the Wichita formation is visible within the section exposed. The conglomerate dips northwest beneath younger Permian shale beds.

According to Chase, the Post Oak conglomerate in the Wichita Mountain area ranges in thickness from 400 feet to 600 feet. On the south side of the mountains the conglomerate dips away from igneous hills, grading from a coarse granite or rhyolite-boulder conglomerate into a coarse cross-bedded arkosic sandstone, which at a distance of six to eight miles south of the mountains interfingers with purplish-red shales. These interstratified beds of arkosic sandstone and shale extend in subsurface a considerable distance south of the mountains with a rather constant thickness of about 400 feet.

0.3	83.8	Cattle guard.
0.15	83.95	Park cars on edge of road as far to right as possible.

STOP 6. Exposure of Reagan conglomerate and sandstone.

NW one-quarter 2-4N-13W.

Assemble at bridge. Walk down embankment on east side of road, crossing fence just below the bridge. Follow stream bank downstream about 100 yards to coarse mass of Reagan conglomerate in stream. Turn left (north) up low hill where coarse rhyolite-porphyry conglomerates of Reagan formation rest on Precambrian Carlton porphyry. Dip of conglomerates here is 10-15 degrees NE.

On top of hill observe quartzitic phase of Reagan sandstone. Continue down dip of Reagan toward large prospect hole dump pile on south side of larger hill to north which is composed of "punky" leached fine-grained brown calcareous sandstones of the Honey Creek formation.

At base of hill are highly glauconitic sandstone (greensands) of the upper Reagan. Throughout the northeastern Wichita Mountains the upper sandstones of the Reagan are very highly glauconitic. These sandstones become slightly more calcareous near the top until pockets and lenses of coarsely crystalline limestone appear in the section. The appearance of the coarsely crystalline glauconitic limestone phase is considered the base of the Honey Creek formation.

Near the top of the greensands of the Reagan formation, about five feet of rhyolite pebble conglomerate is present. The contact of the Reagan and Honey Creek formation is about two feet above the top of the conglomerate.

The prospect pit was begun in the Honey Creek sandstones and is about 40 feet deep, extending into the Reagan.

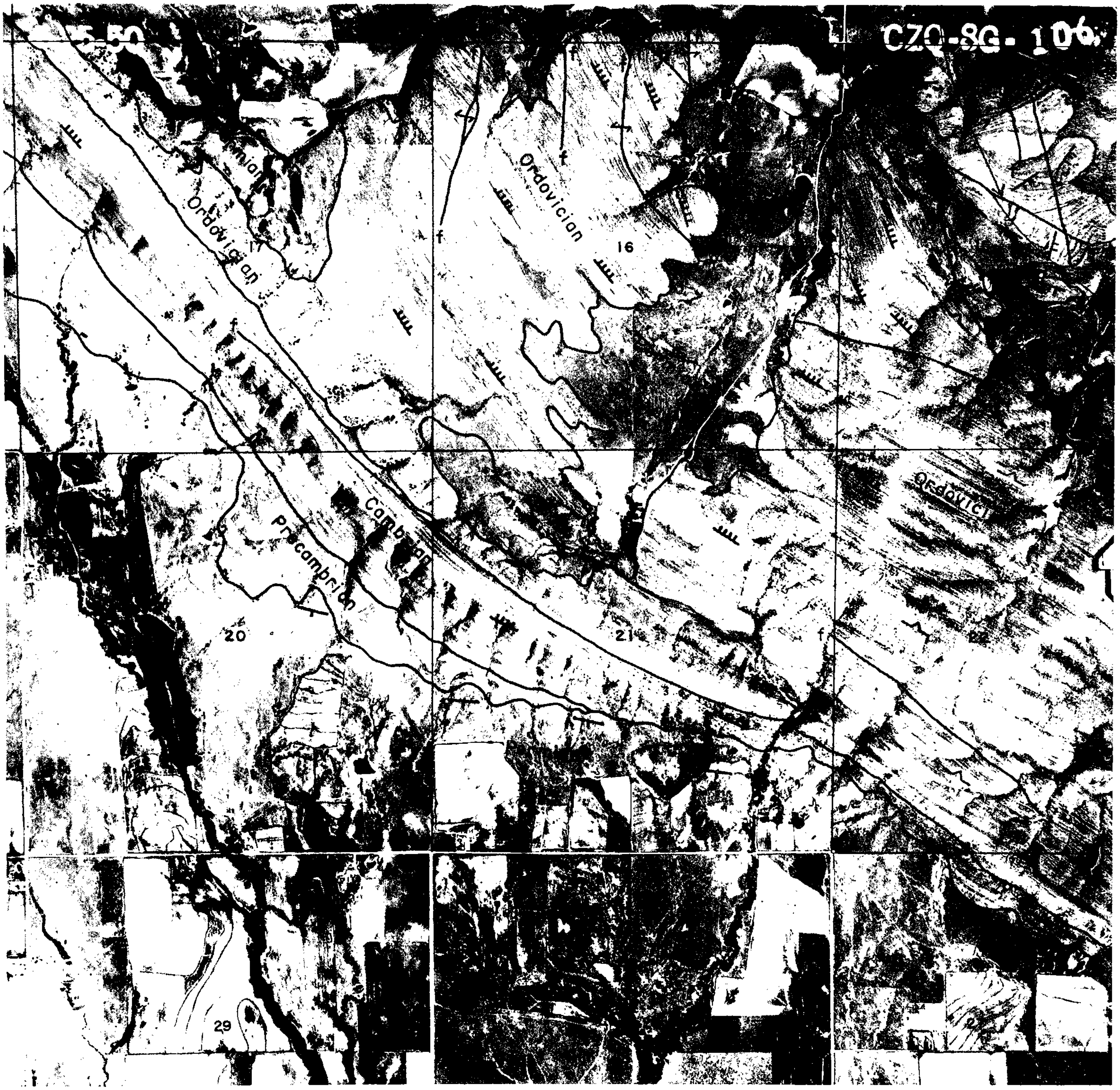
Section at STOP 6

Honey Creek Formation

Reagan Formation

	Thickness (feet)
3. Sandstone, mostly thin-bedded, varying from one inch to one foot, dark green, highly glauconitic, medium-grained, arkosic. Contains five foot rhyolite porphyry pebble conglomerate seven feet above base -------	12
2. Sandstone, medium-bedded, grayish-brown, quartizitic, medium-to coarse-grained, becoming coarser with increasing amounts of iron-oxide cement toward top ---------	30
1. Conglomerate, massive, reddish brown, cobbles and boulders of rhyolite porphyry in a coarse arkosic matrix ----------	15

Carlton porphyry



Dip group 1 = 1° to 3°

Dip group 2 = 3° to 10°

Dip group 3 = 10° to 25°

Dip group 4 = 25° to 45°

Dip group 5 = 45° to nearly vertical

Bedding appears vertical on photos

Airphoto of central portion of T. 4 N., R. 12 W., Comanche County, Oklahoma.

Structure by Geophoto Services.

Cambrian-Ordovician contact from Harlton (AAPG, 1951).

0.5	84.0	Continue ahead. Arbuckle ls. outcrop on right (west).
0.2	84.2	Spring on right (west).
0.2	84.4	Carlton porphyry on east (left) and underneath road bed. Honey Creek formation nonconformably on porphyry on west (right) side of road. Continuing southward observe the contact of the Honey Creek and porphyry striking up the side of the hill so that within a short distance only the porphyry is observable on the west side of the road.
0.7	85.1	Shales, sandstones and conglomerates of the Wichita formation exposed in low hill to the west (right).
0.3	85.4	Cattle guard.
1.1	86.5	Cattle guard.
0.5	87.0	Curve (south) right at Y, staying on gravel road.
0.55	87.55	Turn right (west) off road at rock-veneered house. Follow winding road behind house through two wire gates to hill.
0.2	87.75	Park in pasture as directed by flagmen.

STOP 7. Exposures of Honey Creek formation and part of Fort Sill formation. ("Basal limestone locality"). Dip 35°-45° N. NE one-quarter 24-4N-13W.

The Honey Creek formation at this locality is distinctive because of the presence of a relatively thick sequence of dense limestones below the calareous sandstone facies of the Honey Creek formation. At the last stop, one and one-half miles north, sandstones of the Honey Creek extend nearly to the base of the formation, whereas here over 80 feet of limestones occur at the base of the Honey Creek illustrating the lens-like character of the sandstone. Thickness of the sandstone facies of the Honey Creek formation ranges from 105 feet at this locality to over 250 feet two miles north.

In earlier publications the sandstones at this stop were interpreted as Reagan and the underlying limestone was believed to be pre-Reagan in age and was termed the Basal Limestone. This interpretation is understandable inasmuch as the limestone is considerably more dense and less glauconitic than the more typical Honey Creek limestone. However, the limestone contains fossils of lowermost Honey Creek age thus indicating that a complete or nearly complete sequence of Honey Creek beds is present here.

Measured section at STOP 7

	Thickness (feet)
Ft. Sill formation, upper part covered	
1. Limestone, ranges from thick-bedded to flaggy, dove-gray to purplish, dense, finely crystalline, becoming more dolomitic near top. Some beds contain algae and siliceous sponge spicules ------------------------------	300 plus
Honey Creek formation	
4. Limestone, thin-to medium-bedded, gray, medium-to coarsely crystalline, glauconitic, weathers irregularly because of thin irregular laminae of fine sand and silt ----	10
3. Covered zone - probably thin limestones and shale. Few beds exposed --	40
2. Sandstone, thin-bedded, brown, fine-grained, calcareous, weathers to a punky, porous rock as a result of leaching	

OF CALCIUM CARBONATE. SCATTERED BEDS OF MEDIUM-CRYSTALLINE, GLAUCONITIC LIMESTONES CONTAINING STRINGERS AND LAMINAE OF SILT AND FINE SAND INTERBEDDED WITH SANDSTONE ---105

1. LIMESTONE, THIN-TO-MEDIUM-BEDDED, GRAY TO PINKISH-GRAY, DENSE, FINELY CRYSTALLINE, CONTAINING NUMEROUS FRAGMENTS AND OCCASIONAL COBBLES AND BOULDERS OF UNDERLYING RHYOLITE PORPHYRY -- 85

PRECAMBRIAN CARLTON RHYOLITE PORPHYRY

A SMALL EXPOSURE OF PRECAMBRIAN IGNEOUS ROCK IS PRESENT IN THE FLAT JUST SOUTH OF THE SEDIMENTARY LAYERS. THE ROCK IS THE CARLTON RHYOLITE; IT IS APHANITIC IN TEXTURE AND DULL RED IN COLOR. IN PLACES THE ROCK SHOWS FLOW STRUCTURE AND CONTAINS ROUNDED TO ANGULAR MASSES AND IS INTERPRETED AS A VOLCANIC BRECCIA.

THE CARLTON RHYOLITE IS THE MAIN ROCK IN THE FORT SILL MILITARY RESERVATION AND ALSO OCCURS IN THE CENTRAL PART OF THE LIMESTONE HILLS, THAT IS, ALONG THE AXIS OF THE BLUE CREEK CANYON ANTICLINE.

0.25	88.0	RETRACE ROUTE TO GRAVEL ROAD. TURN RIGHT (SOUTH).
0.8	88.8	HIGH MOUNTAIN AHEAD ON RIGHT IS MT. SCOTT, HIGHEST IN WICHITA MOUNTAIN SYSTEM.
0.7	89.5	ROAD INTERSECTION. TURN RIGHT (WEST) AT APCO SERVICE STATION.
4.0	93.5	MEERS POST OFFICE, TURN LEFT (SOUTH). IN ROADCUT ARE HIGHLY DISINTEGRATED GABBROS.
0.6	94.1	PARK AS CLOSE TO SHOULDER OF ROAD AS POSSIBLE AND PULL UP CLOSE TO CAR AHEAD.

STOP 8. Meers quartzite at type locality. NE one-quarter SE one-quarter 32-4N-13W.

This quartzite is the oldest known rock in Oklahoma. It occurs as a small mass adjacent to and below the road and is an inclusion in gabbro. The Meers quartzite is compact, dense, and varies in color from white to dark gray. A thin section reveals its composition to be quartz 91 per cent, sillimanite 5 per cent, biotite 3 per cent, magnetite 1 per cent, with traces of zircon and apatite. The quartz grains are sub-angular to rounded and average 0.25 mm in diameter. Sillimanite occurs as slender needles up to 0.5 mm in length, and probably developed by the metamorphism of clay impurities in the original sandstone.

In addition to this small exposure there is an outcrop of quartzite along the banks of the nearby Medicine Bluff Creek. This latter is roughly circular in outline with a diameter of one-quarter of a mile. It is surrounded by gabbro. A third exposure of quartzite is present on top of the hill in SE one-quarter SW one-quarter SE one-quarter 34-4N-14W. It crops out in an area about 50 by 200 feet and is surrounded by granite.

The Meers quartzite outcrops are remnants of the country rock which was intruded and metamorphosed by basic and silicic magmas in Precambrian times. The sediments probably were widespread in the Wichita Mountain area and the pebble xenoliths in Lugert granite described in STOP 6 (May 2) may be a part of the Meers sedimentary series.

0.2	94.3	Medicine Creek. Three miles east it empties into Lake Lawtonka.
0.2	94.5	East of road, concealed from view, is a Spanish arrastra or ore mill supposedly built in 1820. This stone mill, containing 2

		STONES THAT WERE DRAGGED IN A CIRCULAR TROUGH, IS THE PROTOTYPE FOR MODERN WET-PAN GRINDERS.
0.5	95.0	CATTLE GUARD. ENTRANCE TO WICHITA MOUNTAIN WILDLIFE REFUGE. SPEED LIMIT 35 MPH. TO RIGHT IS MOUNT SHERIDAN.
1.5	96.5	DIRECTLY WEST ARE STONE BUILDINGS USED IN THE NATIONALLY FAMOUS WICHITA MOUNTAIN EASTER PAGEANT.
0.2	96.7	CURVE LEFT AT Y.
0.2	96.9	CURVE LEFT AND CONTINUE EAST TOWARD MT. SCOTT.
2.7	99.6	TURN LEFT ON MT. SCOTT ROAD.
0.25	99.85	ON LEFT ARE LARGE GRANITE BOULDERS FORMING A STABILIZED BOULDER STREAM. MOUNTAIN IS COMPOSED OF PINK FINE-GRAINED GRANITE GENERALLY CALLED LUGERT.
2.55	102.4	STOP 9. TOP OF MT. SCOTT. SE ONE-QUARTER 11-3N-13W. ELEVATION 2,464.

MT. SCOTT IS COMPOSED OF "LUGERT" GRANITE, MEDIUM-CRYSTALLINE, REDDISH ROCK WITH MANY SMALL SEGREGATIONS RICH IN HORNBLENDE. THE MODE OF THE GRANITE IS ORTHOCLASE AND MICROPERTHITE 64.8 PER CENT, QUARTZ 29.8, HORNBLENDE 3.8, MAGNETITE 1.5, AND TRACES OF BIOTITE, SPHENE, ZIRCON, FLUORITE, APATITE, AND HEMATITE. THE ROCK HAS BEEN MAPPED AS LUGERT BUT IT IS NOT ESTABLISHED THAT IT CORRELATES WITH THE GRANITE OF THE TYPE LOCALITY AT LUGERT.

THE "LUGERT" GRANITE IS WIDESPREAD IN THE EASTERN PART OF THE WICHITA MOUNTAINS AND, AT LEAST IN PART, IS A SILL AS IT APPEARS IN THAT FORM ON THE TOP OF MT. SHERIDAN.

THE ROCKS OF THE EASTERN WICHITA MOUNTAINS HAVE THE FOLLOWING AGE RElationships, from youngest to oldest: dike rocks (aplite, pegmatite, and diabase), Quanah granite, "Lugert" granite, Carlton rhyolite, andesite dikes, gabbro-anorthosite, and Meers quartzite.

A very fine-grained rock known as the Davidson granophyre is found in the Mt. Scott-Easter Pageant area and there is a question as to whether it is a granitic rock or part of the Meers quartzite.

Radiometric age determinations on zircon crystals obtained from a granite pegmatite associated with Quanah granite gave a value of 640 million years. This would place it in late Proterozoic.

The top of Mt. Scott is the highest point in the Wichita Mountains and on a clear day affords an excellent view of the topography of the area. A few of the many features worthy of note are given here. To the south is Lake Thomas and to the east Lake Lawtonka (elevation 1,350), both having been formed by the damming of streams. Lake Lawtonka furnishes water for the city of Lawton. The small village south of the lake is Medicine Park and beyond is Fort Sill Military Reservation. The major rock in this Reservation is Carlton rhyolite which forms a bluff 400 feet high along Medicine Bluff Creek. The rhyolite may be detected by the smooth, rounded hills of the exposures. The rock in places shows flow lines and devitrified glass and appears to be a lava rock.

To the southwest may be seen the more jagged hills which are composed of Quanah granite. Mt. Sheridan with its cap of granite is a prominent feature to the west. To the north are the Limestone Hills where stops 5, 6, and 7 were made.

2.8	105.2	Retrace route to main park road. Turn left (east)toward Medicine Park.
1.7	106.9	Cattle guard. Leave Wichita Mountain Wildlife Refuge. Road now is designated state highway 49.
0.4	107.3	Medicine Park to left. State Fish Hatchery on right and left.
0.05	107.35	Intensely jointed rock in roadcuts is Carlton rhyolite.
0.75	108.1	Bridge over Medicine Creek.
0.3	108.4	Granite conglomerate phase of the Post Oak member of Wichita formation, exposed in roadcut.
5.8	114.2	STOP. Junction with U.S. highways 62, 277, and 281. Curve right (south) to Lawton.
1.8	116.0	Entrance to Fort Sill Military Reservation. Speed limit 35 MPH.

Fort Sill - Lawton Oil District

Production in the Lawton-Fort Sill district is primarily from shallow lensing sands and conglomerates in lower Permian (Garber, Wichita-Albany, and Ponotoc) rocks. Lawton field was discovered in 1904, whereas the Fort Sill area first produced oil in 1925. North and northeast of the Fort Sill Military Reservation, Permian clastics increase in thickness and rest on a belt of pre-Permian rocks along the northeast front of the Wichita Mountains. The northwest-trending belt is made up of a complex of folds, some of which are overturned, with both normal and reverse faulting. In the Lawton area, Permian sands and conglomerates rest on eroded Arbuckle limestone and produce 37° gravity oil from a depth of about 250 feet.

0.8	116.8	Medicine Creek.

0.6 117.4 U. S. Military Artillery Museum.

Fort Sill

The present site of Fort Sill in the early part of the 19th century was inhabited by Wichita Indians. After being evacuated by the Indians in 1852, because of malaria, the site was deserted until 1868, when Camp Washita was established here by General Phillip H. Sheridan of Civil War fame. In August, 1869, the post was officially named Fort Sill in memory of Brig. Gen. J. W. Sill, a close personal friend and army companion of Sheridan. Stone for making some of the original buildings was obtained from Quarry Hill, the stone now being called the Fort Sill limestone, basal formation of the Arbuckle group. Satanta, a Kiowa chief, and Geronimo, chief of the Apaches, were imprisoned in the blockhouse of this early-day fort.

With the building of Lawton in 1901, when this part of Oklahoma was opened to white occupation, Fort Sill was no longer the principal local settlement. The post was enlarged in 1909 and a School of Fire for field artillery was established here in 1911. Fort Sill is now one of the largest army posts in the United States, and it also is the testing grounds for atomic cannon.

1.4 118.8 Railroad crossing.

0.25 119.05 Hwy. intersection.

1.85 120.9 Lawton city limits.

0.8 121.7 Downtown Lawton.

END OF SECOND DAY

ROAD LOG FOR SATURDAY, MAY 4

Caravan assembles 6.5 miles north of Lawton on U. S. Hwys. 62 - 277 - 281 at junction with Oklahoma Hwy. 49, heading north. Departure at 8:00 A.M.

0.0	0.0	Junction Hwys. 62 - 277 - 281 and 49.
1.5	1.5	In road cuts are maroon shale and pink arkose in Wichita formation.
2.2	3.7	RAILROAD CROSSING. CAUTION. Turn left (west) across tracks on road to quarry.
0.6	4.3	Turn right into parking area.

STOP 1. Arbuckle limestone at Richards Spur quarry of Dolese Brothers Company. SW one-quarter 31-4N-11W. Leading producer of crushed stone in Oklahoma.

This quarry, located at the southeastern end of the Limestone Hills, has been in operation since 1904. After being destroyed by fire in 1949, the plant was rebuilt and put back into operation in 1952, at which time it was described in leading trade journals as the "nation's outstanding new crushed stone plant". Produced at the quarry is a wide variety of stone products, chiefly high-grade aggregate for concrete and asphaltic road construction but including also railroad ballast, riprap, agricultural limestone, and ground limestone for topping asphaltic roads. One special feature of the plant is a panel board control to blend various sizes of crushed stones in accurate proportions for exacting aggregate specifications.

The quarry is worked from virtually inexhaustible reserves in the Ar-

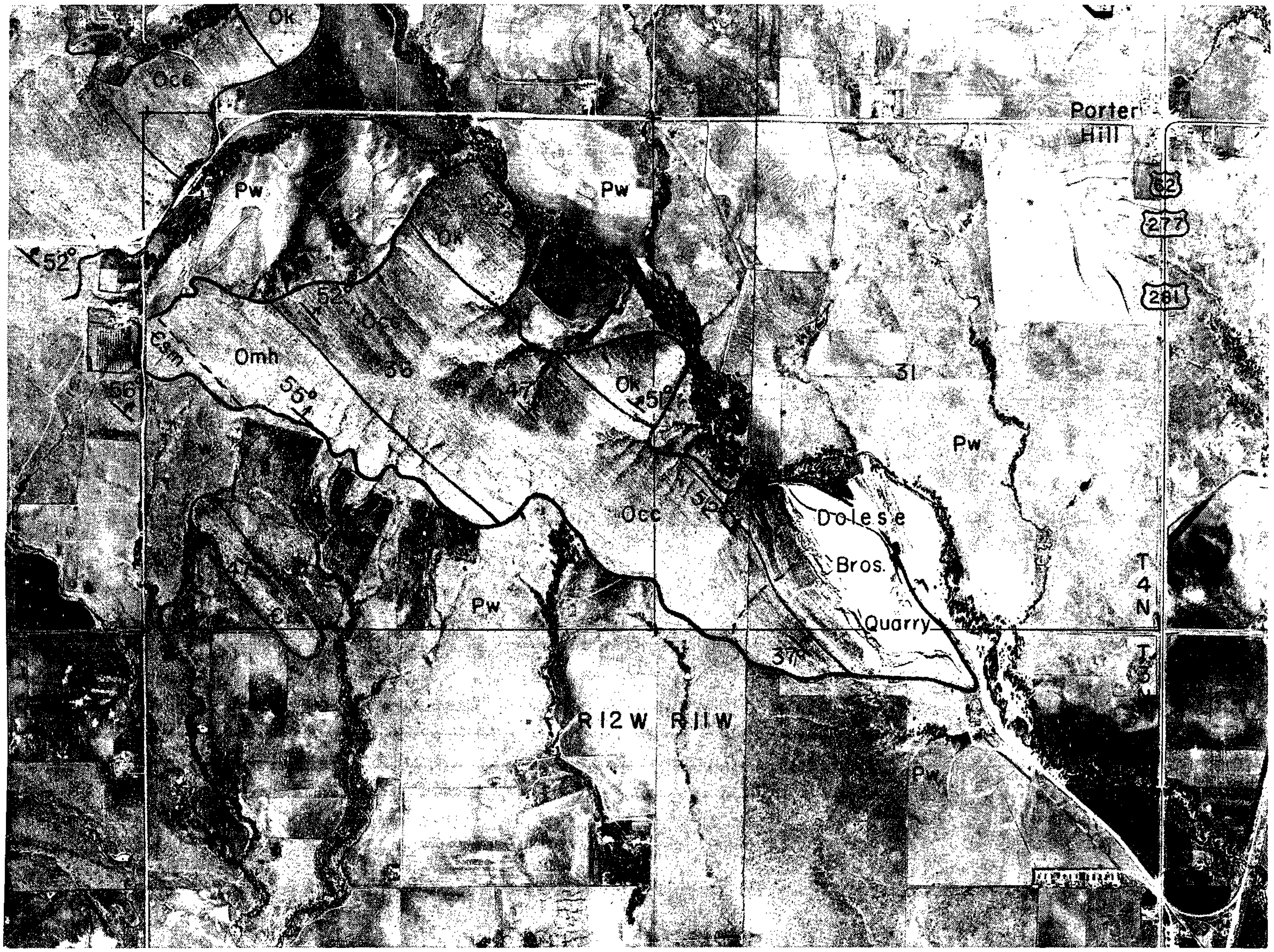


Figure II. Aerial photograph showing geology of Arbuckle limestone in vicinity of Richards Spur quarry of Dolese Brothers Company.
Cfs, Fort Sill ls ; Csm, Signal Mountain ls.; Omh, McKenzie Hill ls.; Occ, Cool Creek ls.; Ok, Kindblade ls.; Pw, Wichita formation.
U.S. Department of Agriculture photo, 1942. Dashed line shows present outline of quarry.

buckle limestone that crops out as ridges in several northwest-trending belts for 25 miles along the northeast flank of the Wichita Mountains. These hog-back ridges project abruptly upward 300-400 feet above the surrounding plains of shale in the Wichita formation.

Arbuckle limestone, with a total exposed thickness of 4,000 feet, is the dominating rock in the Limestone Hills. A comparatively small outcrop area of Honey Creek limestone and Reagan sandstone is exposed along the axis of the Blue Creek Canyon anticline (Stops 6 and 7 of May 3); and an even smaller area of Viola limestone and strata of the Bromide formation is exposed in the Rainy Mountain syncline (Stop 4 of May 3).

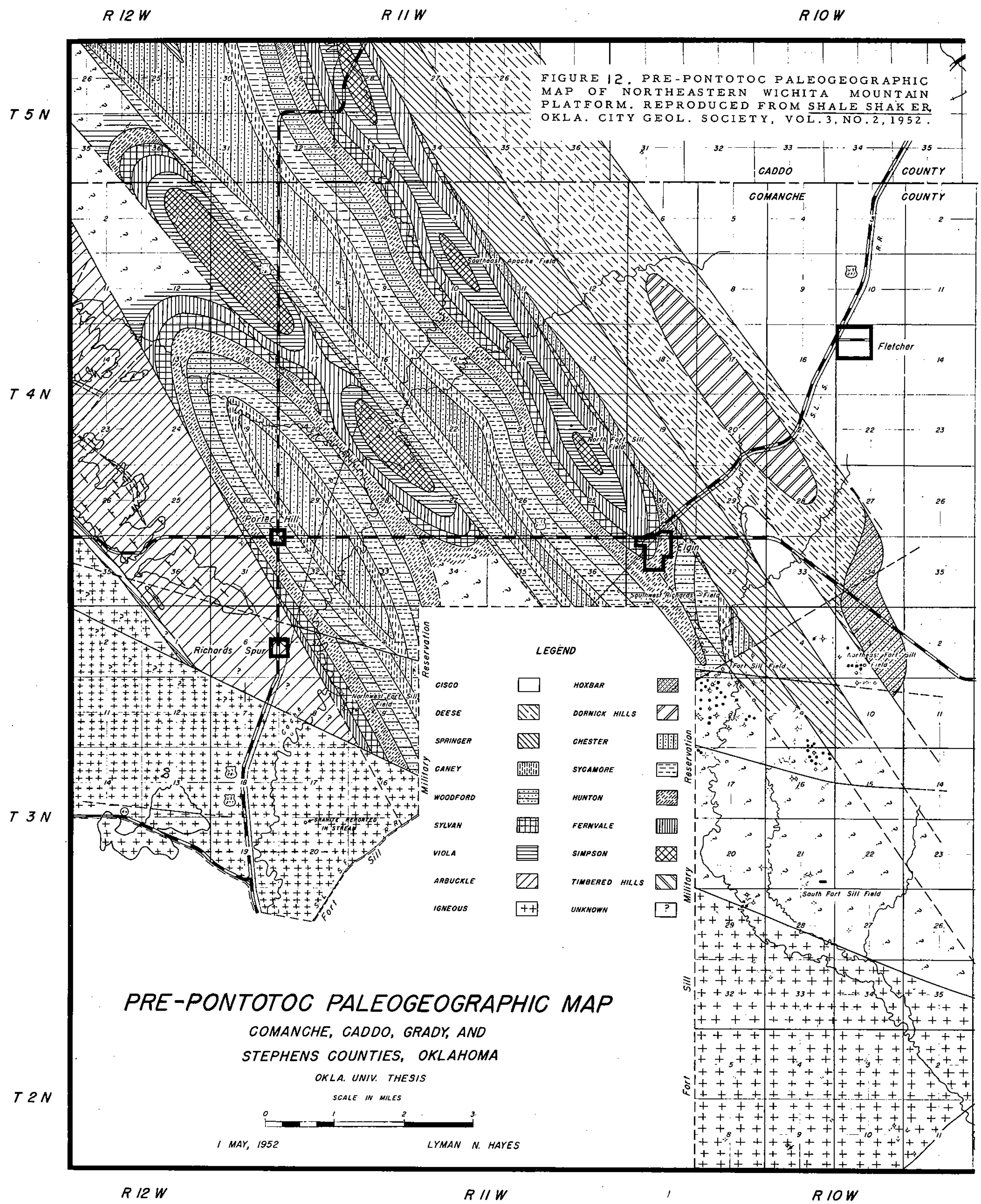
Together these rocks form the exposed part of the highly folded and locally strongly faulted frontal belt that has yielded such oil pools as Apache. The belt of highly folded rocks extends from this area in subsurface northeastward for a width of 10 miles before passing into the gently folded Anadarko basin. An interpretation of the subsurface folding and faulting is given in the cross-section of Figure 13. Note from the cross-section that the platform here is cut on folded Paleozoic rocks, whereas north from the western part of the Wichita Mountains this platform is cut chiefly on Precambrian granite and has much greater width (Figure 1.)

In the face of the Richards Spur quarry the strata dip 35° northeast, exposing about 500 feet of Arbuckle limestone in the Cool Creek and Kindblade formations, middle Lower Ordovician in age. The upper beds in the quarry are identified from characteristic sponges (*Archaeoscyphia*) and species of *Ceratopea* as lower Kindblade, about 2,500 feet below the top of the Arbuckle group.

These strata are equivalent to the lower part of the Honeycut formation of the Ellenburger group in central Texas. Most of the stone in the face is Cool Creek limestone, characterized by a high content of sand grains and chert, part of which is oolitic. Diagnostic fossils are the gastropod Lecanospira and the brachipod Diaphelasma, which serve to correlate the Cool Creek with the Gorman formation in the Ellenburger group of Texas. Predominant lithology of the Cool Creek and Kindblade formations is fine-grained compact medium-gray limestone, with which are interbedded numerous layers of pellet limestone, algal limestone, oolitic limestone, and intraformational limestone conglomerate.

Sediments of the Wichita formation and possibly of the Hennessey shale covered the Limestone Hills in lower Permian time. Solution-widened joints filled with red clay containing bones of small Permian reptiles and amphibians have been found at several places in the Arbuckle limestone at the quarry. Many of these bones are of the genus Captorhinus, a slender long-tailed terrestrial reptile about 2 feet long. This filling obviously came from Permian sediments that had collected in caves and sinks at higher levels of the limestone. Moreover, the Limestone Hills are everywhere flanked by strata of the Wichita formation, including limestone conglomerate of the Post Oak member that was derived from the hills locally and which disappears in subsurface by wedging outward into shale. The lowest hills are just now being uncovered by erosion of these lower Permian sediments.

0.7	5.0	Retrace route to Hwy. 281. STOP. Turn left (north).
0.9	5.9	Roadcut exposures of thin-bedded feldspathic sandstone in



R 12 W
R 11 W
R 10 W
T 5 N
T 4 N
T 3 N
T 2 N
FIGURE 12. PRE-PONTOTOC PALEOGEOGRAPHIC MAP OF NORTHEASTERN WICHITA MOUNTAIN PLATFORM. REPRODUCED FROM SHALE SHAKER, OKLA. CITY GEOL. SOCIETY, VOL. 3, NO. 2, 1952.
CADDO COUNTY
COMANCHE COUNTY
Southeast Apache Field
Fletcher
North Fort Sill Field
Porter Hill
Elgin
Southwest Richards Field
Richards Spur
Northwest Fort Sill Field
Fort Sill Field
Northeast Fort Sill Field
South Fort Sill Field
GRANITE REPORTED IN STREAM
Fort Sill Military Reservation
LEGEND
CISCO
DEESE
SPRINGER
CANEY
WOODFORD
SYLVAN
VIOLA
ARBUCKLE
IGNEOUS
HOXBAR
DORNICK HILLS
CHESTER
SYCAMORE
HUNTON
FERNVALE
SIMPSON
TIMBERED HILLS
UNKNOWN
PRE-PONTOTOC PALEOGEOGRAPHIC MAP
COMANCHE, CADDO, GRADY, AND STEPHENS COUNTIES, OKLAHOMA
OKLA. UNIV. THESIS
SCALE IN MILES
0 1 2 3
1 MAY, 1952
LYMAN N. HAYES

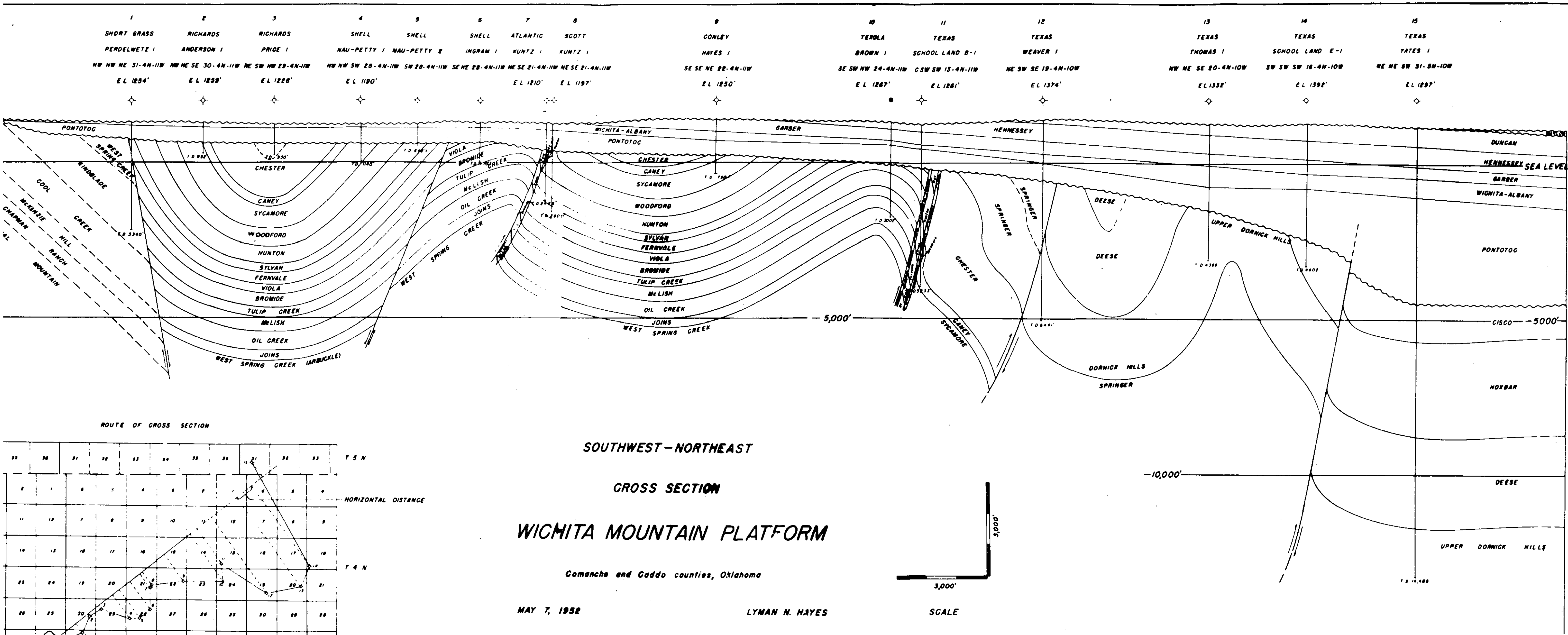


FIGURE 13. SUBSURFACE SECTION ACROSS NORTHEASTERN WICHITA MOUNTAIN PLATFORM. REPRODUCED FROM SHALE SHAKER, OKLA. CITY GEOL. SOC., VOL. 3, NO. 2, 1952.

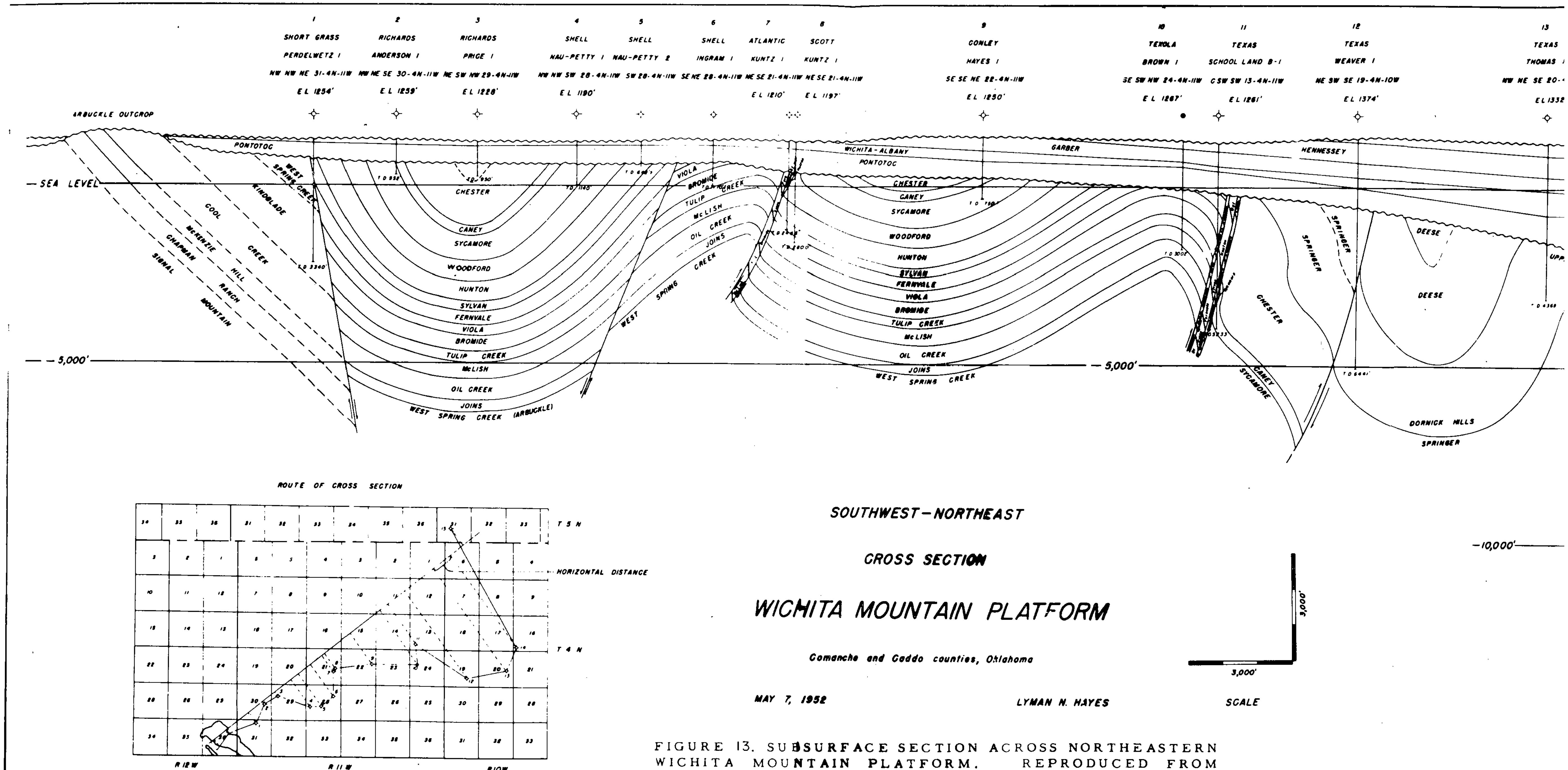


FIGURE 13. SUBSURFACE SECTION ACROSS NORTHEASTERN WICHITA MOUNTAIN PLATFORM. REPRODUCED FROM SHALE SHAKER, OKLA. CITY GEOL. SOC., VOL.3, NO. 2, 1952.

WICHITA FORMATION, "T-BED" OF GEOLOGIC MAP OF OKLAHOMA, 1954, EQUIVALENT TO BASE OF GARBER SANDSTONE.

0.6	6.5	PORTER HILL. CONTINUE NORTH ON HWYS. 62-281.
0.3	6.8	ROAD CUTS IN CROSS-BEDDED LIGHT YELLOWISH BUFF SANDSTONE AND SHALY SILTSONTE; "T-BED" OF STATE MAP, PROBABLY EQUIVALENT TO BASE OF GARBER SANDSTONE WHICH HAS BEEN MAPPED OVER MANY TOWNSHIPS IN SOUTH-CENTRAL OKLAHOMA.
1.3	8.1	CHANDLER CREEK, STEEL BRIDGE.
1.4	9.5	HISTORICAL MARKER, COMMEMORATING CAMP COMANCHE SET UP IN 1834 BY COL. DODGE OF FIRST DRAGOONS.
1.1	10.6	GRAVEL PIT ON HILL TO WEST, AT CROSS-ROAD.
0.4	11.0	APPROXIMATE CONTACT OF WICHITA FORMATION WITH OVERLYING HENNESSEY SHALE.
0.6	11.6	ENTER CADDO COUNTY, LEAVE COMANCHE COUNTY.
0.9	12.5	SHARP CURVE TO RIGHT. SLOW TO 45 MPH.
0.8	13.3	RAILROAD CROSSING.
0.1	13.4	APPROACHING CURVE. SLOW. GRAVELS ON LEFT ARE PARTLY INDURATED, CONTAIN ELEPHANT TEETH. CONTINUE STRAIGHT AHEAD (EAST) ON GRAVEL ROAD, LEAVING HIGHWAY.
0.6	14.0	WEST CACHE CREEK, STEEL BRIDGE. CURVE RIGHT (EAST) ACROSS BRIDGE.
0.5	14.5	SECTION CORNER. TURN LEFT (NORTH).
0.9	15.4	PARK CARS WELL TOWARD RIGHT OF ROAD.

STOP 2. <u>DUNCAN SANDSTONE EXPOSED IN EAST ROADCUT NEAR SOUTHEAST EDGE OF APACHE.</u> NW ONE-QUARTER NW ONE-QUARTER 27-5N-11W.

Northward from the Arbuckle inliers near Richards Spur are gently northeast-dipping mostly homogeneous shales of the Wichita and Hennessey formations. The plains developed on these shales are terminated on the northeast by a low escarpment of the Duncan sandstone. At Apache this escarpment is 80 feet high.

Beginning with the Duncan sandstone, and continuing upward through slightly more than 1,000 feet of middle Permian strata, are chiefly sandstones, together with some shales and intraformational mudstone conglomerates, which are divided stratigraphically into the El Reno group below and the Whitehorse group above. Whitehorse sandstones have essentially similar characters throughout most of western Oklahoma. Rocks of the El Reno group, however, are of clastic derivation only for about 100 miles along the outcrop in the southeastern part of the Anadarko basin, grading northward and westward on both flanks of the basin into gypsum, dolomite, and shale. The westward evaporite facies in the middle of the El Reno group is characterized by thick gypsums in the Blaine formations, seen at STOP 2 of May 2.

At Apache, on the south limb of the Anadarko basin near its southeastern terminus, the Duncan sandstone is a recognizable unit of yellowish gray fine-grained sandstone interbedded with shales. Here the stratigraphic relations are somewhat obscure. The 20 feet of sandstones exposed in the roadcut are believed to be upper Duncan, the lower 60 feet having graded into shale from the type locality at Duncan, where the sandstone is 125 feet thick.

Post-Duncan beds of the El Reno group will not be seen in this area. These strata are 350-550 feet thick and consist of cross-bedded sandstone, purplish mudstone conglomerate, and shales in a complex sequence generally classified as Chickasha formation. Wedging in at the top is maroon Dog Creek shale, which disappears eastward by grading into the upper beds of the Chickasha. The Flowerpot shale of the western area is absent here, the horizon being represented by lower Chickasha sandstones and intraformational conglomerates.

0.9	16.3	East edge of Apache. CAUTION. Continue ahead, north.
0.3	16.6	Junction with U.S. Hwys. 62 and 281. STOP. Continue ahead (north) on 281.

Apache Field

Four miles northwest of Apache townsite is the Apache field, the most important new pool discovery in Oklahoma for the year 1941. The discovery resulted from extensive surface and seismograph surveys of the area. Texas Company No. 1 Smith (C NE one quarter NW one quarter 2-5N-12W) spudded in 1938 was plugged in 1941 in order to conserve gas, so that the No. 2 Smith (C SE one-quarter NW one-quarter 3-5N-12W) was credited as the actual discovery well of the pool. Completed in September, 1941, the well flowed 1,466 barrels of 39.2° gravity oil in 24 hours, with an estimated 3 million cubic feet of gas from Bromide sand at a total depth of 3,433 feet. Accumulation of oil in this field containing 2,000 proved acres is related to an overturned fold with probable faulting on the northeast flank. Dips as steep as 67° have been measured in cores, and duplicated sections have been drilled. The Apache structure is in the highly deformed belt of the northeast Wichita Mountain front. Lower Ordovician Arbuckle limestone is exposed in 19-5N-12W, approximately 4 miles southwest, and granite crops out in 12-4N-13W, about 8 miles southwest of the field.

Fifty oil wells have been drilled in the field, of which 42 produced 284,048 barrels during 1955. Cumulative production was 22,015,550 barrels at the end of 1955. Bromide sands in this field have produced as much as 25,000 barrels per acre. Total production of the field estimated in 1951 was 30 million barrels.

Northeast Alden field, approximately 6 miles northwest of Apache field, is heralded as one of the most important discoveries of 1956 for Oklahoma. Sinclair-Cities Service et al No. 1 Susie (C NW one-quarter SE one-quarter 1-6N-13W), completed September 11, flowed 553 barrels of 37.5° oil in 18 hours from Bromide sands between 8,711 to 8,907 feet. This field also is located on the deformed frontal belt of the Wichita Mountains.

1.0	17.6	Cross roads. Hill to east is capped by basal Marlow fine-grained pink sandstone, which rests on Dog Creek maroon shale containing green spots and layers. Contact is rather well exposed in north road cut.
0.3	17.9	Railroad crossing, C.R.I. and P. RR.
0.5	18.4	Box Elder Creek
2.2	20.6	Cross roads.

Cement Field

Five miles to the east is the west edge of Cement field, another of Oklahoma's fields. It already has produced 85 million barrels of oil from more than

20 pay sands ranging in age from Permian to Springeran, and at the end of 1956 estimated reserves were 40 million barrels.

Fortuna Oil Company drilled the discovery well (32-6N-9W) in 1917. The field is located on a complex faulted anticlinal structure from which more than 1,500 feet of Pennsylvanian sediments have been eroded off the top. Some 15,000 acres and 1,300 wells have produced oil at depths ranging from 1,900 to 6,000 feet. In 1956, 1,217 wells produced 4,372,000 barrels of 34° gravity oil.

A great many of the subsurface names for sands and limestones, such as Rowe, Gregory, Niles, Wade, and Culp-Melton, which are used now in regional studies in southern Oklahoma, claim the Cement field as their type locality.

3.2	23.8	Road cuts in Rush Springs sandstone.
1.7	25.5	Park on west side of highway in three parallel lines.
		<u>STOP 3. Rush Springs sandstone well exposed in ravine west of highway.</u> NW one-quarter SW one-quarter 3-6N-11W.

In the southeastern part of the Anadarko basin, sandstones of the Whitehorse group are widely distributed and well exposed in many small canyons and deep ravines. At this locality about 40 feet of even-bedded pale orange-red sandstone in the upper part of the Rush Springs crops out in the walls and along the floor of a ravine. Except in one small area half way up on the east wall, cross-bedding is conspicuously absent. In both higher and lower strata, however, cross-bedding is distinctive and characteristic of the Rush Springs sandstone. This cross-bedding is believed by many, from the long curved sweeps of the fore-set beds, to be formed by eolian action that swept the sand into dunes. On the other hand the sandstone contains abundant feldspar, locally as much as 30 percent, and these grains have authigenic feldspar overgrowths that are believed to form only in marine water. Presumably the sand was deposited on a beach and the feldspar overgrowths were formed when the beach was covered by the sea shortly thereafter.

Being 190 to 250 feet thick, and consisting principally of massive fine-grained sandstone, the Rush Springs is an excellent water-bearing bed and is yielding 100-300 gallons per minute of very slightly mineralized water to irrigation wells in many parts of western Oklahoma.

Subdivision, mapping, and stratigraphic classification of the White-horse sandstone is greatly facilitated by the occurrence within this sequence of two thin dolomite beds and two thin beds of pink shale, each of which shows remarkable continuity and extent (Figure 14). The upper Relay Creek dolomite, 1 - 3 inches thick, divides the Whitehorse group into the Rush Springs sandstone above and the Marlow formation below. Twenty-five to 30 feet below this bed, in the upper part of the Marlow, is the Lower Relay Creek dolomite, also 1 - 3 inches thick. The pink shales are 2—4 inches thick and, being fully as extensive as the dolomites, they are believed to be related to falls of volcanic ash. The Upper Pink Shale is consistently 25-30 feet above the base of the Rush Springs, whereas the Lower Pink Shale is 50-60 below the top of the Marlow.

The Marlow formation, not studied on this trip, is 110-115 feet thick in the southeastern part of the Andarko basin and consists chiefly of orange-red fine-grained sandstone and sandy shale. The lower part typically contains veins of satin spar gypsum and locally a few thin gypsum beds.

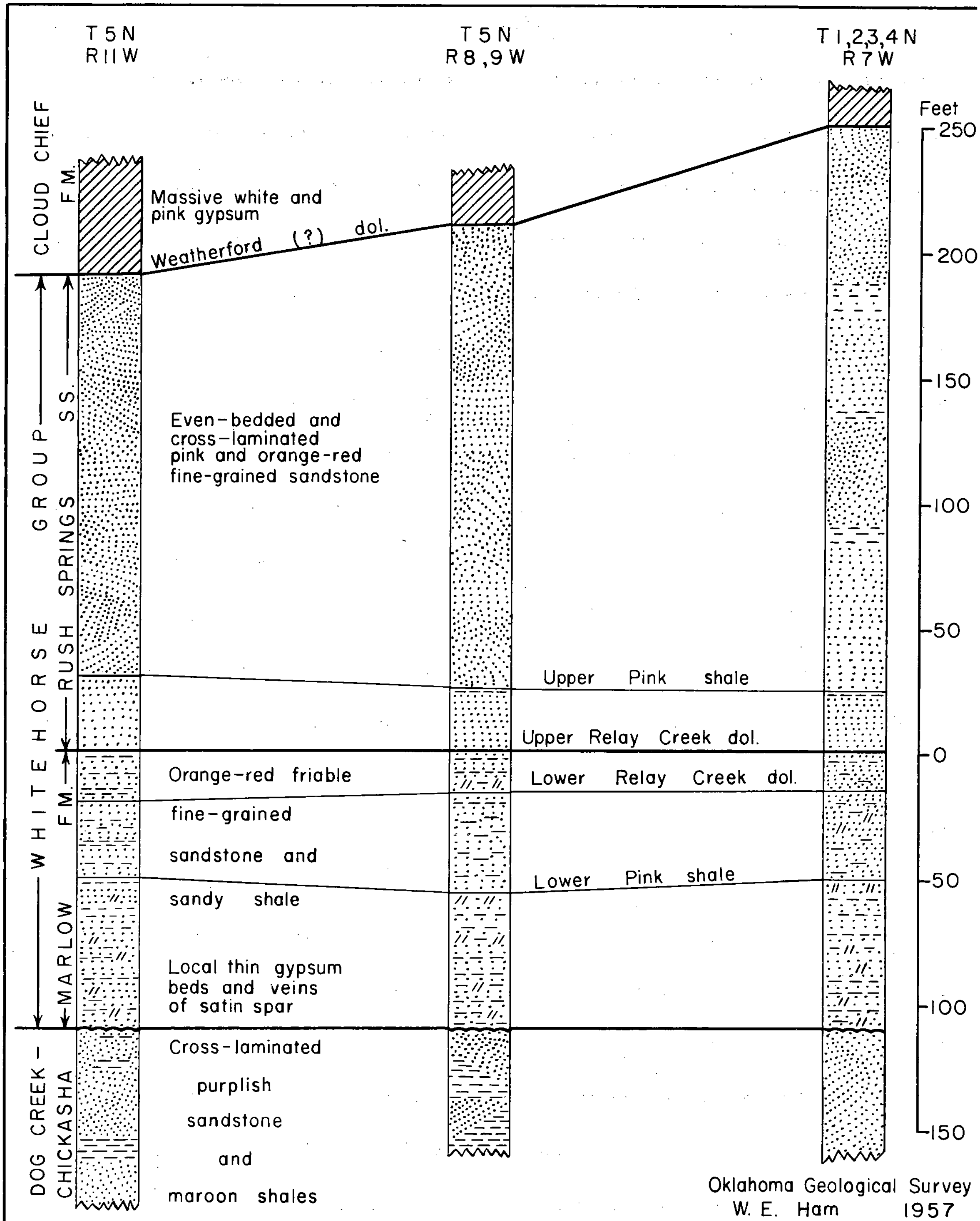


Figure 14. Section of Whitehorse group in southeastern part of Anadarko basin. Slightly modified from guide book of A.A.P.G. Anadarko Basin Field Trip, 1939, Okla. City Geol. Soc.

0.8	26.3	Continue ahead on highway. Poor exposures of Cloud Chief gypsum in road cuts through low hill on curve.
0.9	27.2	Approaching junction with Okla. Hwy. 9. Turn left (west).
0.1	27.3	STOP. Enter Hwy. 9 cautiously.
0.4	28.1	Cloud Chief gypsum exposed in road cuts.
0.1	28.2	Rush Springs sandstone exposed in valley.
0.2	28.4	Park in three lines on right (north) side of highway.

STOP 4. Cloud Chief gypsum with Weatherford (?) dolomite at base. SW one-quarter SW one-quarter 28-7N-11W.

The thickest outcropping evaporite bed in Oklahoma is the gypsum at the base or in the lower part of the Cloud Chief formation, Middle or Upper Permian in age. It crops out over hundreds of square miles in the central part of the Anadarko basin and reaches a maximum known thickness of 90 feet. The gypsum occurs mostly in the form of a massive white to pink layer, containing faint lines of stratification, that weathers to rounded hills marked locally with caves and collapsed sinks. The area of maximum development is in eastern Washita and southeastern Custer Counties, between Cloud Chief and Weatherford, but the outcrop extends as scattered outliers southeastward into Caddo and Grady Counties.

The largest outlier of Cloud Chief gypsum is between Fletcher and Cement, and the next largest outlier is in the area of this stop. Exposed in the roadcuts are the lowest few feet of the gypsum member, underlain by purplish and pink fine-grained laminated dolomite 3 inches to 1 foot thick that probably is equivalent to the Weatherford dolomite. This bed marks the base of the Cloud Chief formation, resting on Rush Springs sandstone, and it can be traced as a valuable marker over much of western Oklahoma.

As much as 50-80 feet of Cloud Chief gypsum is present in the outliers, the full thickness being unknown because the top is eroded. On both flanks of the Anadarko basin to the west, this thick gypsum grades into sandstones and sandy shales that contain only a few lentils of gypsum, so that in westernmost Oklahoma the Cloud Chief formation is composed principally of clastic sediments. Hence the Cloud Chief is the exact opposite of the Blaine formation in distribution of evaporites and direction of clastic-sediment source. The Cloud Chief clastics are derived from the northwest and the evaporites are thickest in the southeast, whereas the Blaine clastics are localized in the southeast and grade into thick evaporites northwestward.

Drilling the Cloud Chief gypsum near Weatherford, to evaluate gypsum deposits for possible economic use, has shown vast reserves of high-purity gypsum as much as 90 feet thick. Part of the gypsum grades into anhydrite in shallow subsurface. Anhydrite doubtless continues westward into subsurface and, together with anhydrite of the Blaine, it makes up a thick succession of evaporites whose underground solution results in the many erratic dips and local structures shown in the outcropping Quartermaster formation.

The outcrops at this last stop of the field trip also have great structural significance, as they are near the axis of the Anadarko basin. The deepest part of the basin is thought to be in the vicinity of the Fort Cobb anticline, about 11 miles northwest, on which Superior Oil Company's No. 51-11 Weller was drilled in 11-8N-12W. The deepest well drilled on the Fort Cobb anticline, it reached a depth of 17,823 feet and was still in Springeran shale. H. F. Suffield (Oil and Gas Journal, December 3, 1956) estimates the following depths for pre-Pennsylvanian formations:

Mississippian	18,300
Hunton	21,500
Viola	22,400
Simpson	23,000
Arbuckle	24,600

Some geologists estimate as high as 26,500 feet to the top of the Arbuckle. Top of the Precambrian granitic rocks thus would be about 33,000 feet, of which about half would represent thickness of Pennsylvanian rocks.

A thickness of 33,000 feet of Paleozoic strata, Cambrian through Permian, would make the Anadarko basin a major depositional trough, certainly one of the deepest in Oklahoma. Significantly this trough borders the Wichita Mountains, which has the maximum outcrop of Precambrian rocks and is thus one of the greatest structural uplifts in the State. The Wichita Mountain-Anadarko basin province magnificently illustrates tectonics on a grand scale.

END OF FIELD TRIP

Amarillo-bound traffic continue west on Hwy. 9 through Fort Cobb to Carnegie, north on Okla. Hwy. 58 to Okla Hwy. 152, then west to junction with U.S. Hwy. 66 at Sayre. Oklahoma City-bound traffic go east on U.S. Hwy. 62 through Anadarko and Chickasha.