STATE OF ARKANSAS

ARKANSAS GEOLOGICAL COMMISSION

Norman F. Williams, State Geologist

A GUIDEBOOK TO THE GEOLOGY OF THE OUACHITA MOUNTAINS, ARKANSAS

by

Charles G. Stone, Boyd R. Haley, and George W. Viele

Little Rock, Arkansas
1973

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ROAD LOG - FIRST DAY

NORTHEASTERN OUACHITA MOUNTAINS, ARKANSAS

Little Rock - Paron - Perryville - Nimrod - Hollis - Jessieville - Mountain Pine - Hot Springs - Little Rock

SUMMARY

Selected stops on this trip include: the Late Paleozoic formations of the large, upright, thrust faulted structures of the Fourche Mountains in the frontal belt; the early Late Paleozoic formations of the very tightly-folded and thrust faulted southern margins of the frontal belt; the Early Paleozoic formations of the most intensely deformed central "core area"; and the Early-to-Late Paleozoic formations of the slightly less complex Zigzag Mountains along the southern border of the "core area" of the Ouachita Mountains.

MILEAGE	DESCRIPTION
0.0	Assemble at 7:15 a.m. on Gaines Street side of Sam Peck Hotel. In this area a thin Tertiary section (Midway-Paleocene - clay, marl, and limestone; and Wilcox-Eocene - gravel, sand and clay) lies unconformably on lower Jackfork Sandstone (Pennsylvanian). This is the Fall Line separating the Gulf Coastal Plain (Mississippi Embayment) from the Interior Highlands. Turn left at stop light on Capitol Avenue and proceed west on Capitol.
0.2	Turn right at stop light onto Chester Street.
0.5	Turn left at stop light onto Ark. Hwy. 10.
	For the next 2.3 miles the route traverses shale and somewhat lenticular sandstone of the lower and middle Jackfork Sandstone along the south bank of the Arkansas River.

1.2 View of Arkansas River to north (right). Northward dipping, highly sheared and faulted lower and middle Jackfork slate and lenticular sandstone to south.

2.7 Ascending Cantrell Hill through exposures of gently northward dipping basal upper Jackfork sandstone, siltstone and shale on the south flank of the Big Rock syncline. In 1931 Hugh Miser collected rather meager fossils from grit layers in this area which were identified by George H. Girty (Miser, AAPG Bull., Vol. 18, 1934, p. 989-991) and more recently examined by Mackenzie Gordon, Jr. (oral communication); both indicated that the fauna is early Pennsylvanian in age.

4.4 Junction with University Avenue; continue west on Hwy. 10.

7.1 STOP 1-1. (25 MINUTES) FAULTED UPPER JACKFORK SANDSTONE AT INTERSTATE 430.

An excellent very deep, new roadcut on Interstate Hwy. 430 in shale, siltstone and massive to flaggy sandstone of the basal upper Jackfork Sandstone on the thrust faulted south flank of the Big Rock syncline. Notice north-dipping fault planes and zones, with numerous slickensides coated with dickite and other minerals. There are several small folds (drag?) overturned towards the south. Closely spaced cleavage generally dips northward less than bedding. Turbidity and sediment-flow features (i.e. bottom marks and graded bedding) suggest proximal flysch deposition. Scant invertebrate remains and probable deep-water trace fossils are also present in the sequence. Hydrothermal quartz veins of probable late Paleozoic age are relatively numerous and contain traces of the unusual clay mineral, rectorite; the rare lithium chlorite mineral, cookeite; and the iron chlorite, thuringite.

At Stop 1-1 we are in a syncline typical of the structure in the southern part of the frontal belt of the Eastern Ouachita Mountains. The folds are

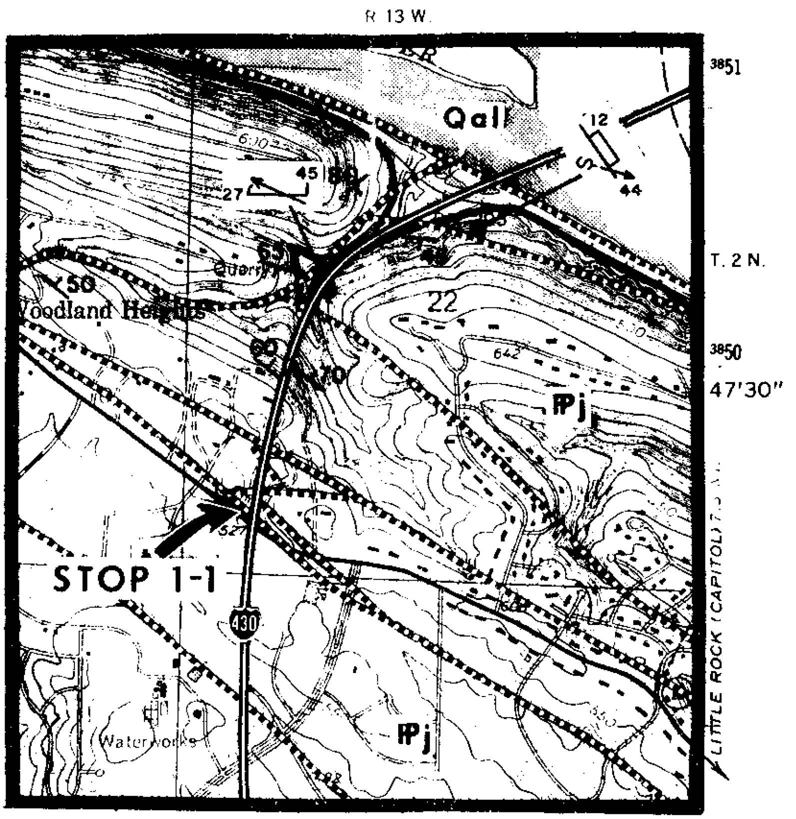


PLATE 1. GEOLOGIC MAP OF PULASKI HEIGHTS AT INTERSTATE HIGHWAY 430- STOP 1-1.

1000 0 1000 2000 3000 FEET

Geology by Stone and Haley

upright or inclined toward the southwest and have horizontal or gently raking hinges. The cleavage planes, which are probably made up of two or more sets, dip toward the north or northeast generally at lower angles than the bedding of either fold limb. Numerous fault planes also dip toward the north. In other nearby localities, for example in railroad cuts near the State Capitol, the folds incline southwestward, but the hinge lines are reclined and lie in the northeast-dipping cleavage. North of Stop 1-1 and the Arkansas River, some folds are down facing toward the north and appear to have formed by cascading down a north-dipping slope. These relations suggest multi-phase deformation. Perhaps the initial direction of tectonic transport was towards the north and a later compression of the rocks in situ formed the cleavage, the reclined folds, and the small thrust faults.

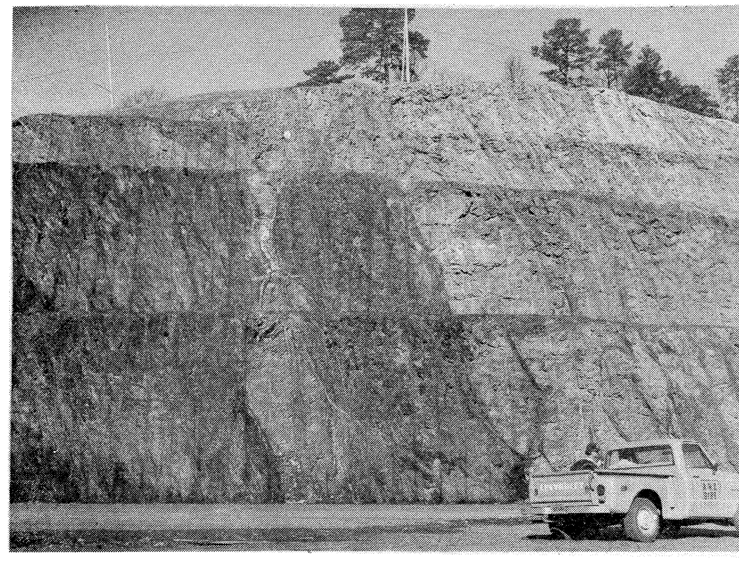
7.5 Continue west on Ark. Hwy. 10. Exposures of the northeastward dipping lower and middle Jackfork Sandstone are traversed for the next 7.0 miles. Generally the maroon-gray slate and brown sandstone is sheared and is broken and filled with milky quartz veins containing cookeite. Abundant invertebrate fossils have been obtained in recent years by Mackenzie Gordon, Jr., Hugh Miser, Charles Stone and others from lenticular sandstone masses from the middle of the Jackfork Sandstone in the region. These fossils have been assigned a definite early Pennsylvanian age by Mackenzie Gordon, Jr., an interpretation which has been confirmed by others.

8.1 Turn south off Ark. Hwy. 10 onto Rodney Parham Road.

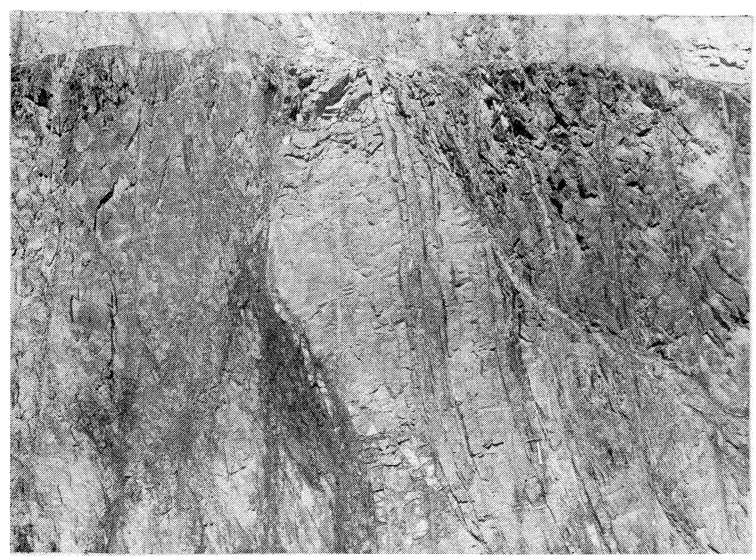
8.7 Large quartz veins to right in faulted northward dipping middle Jackfork shale and sandstone contain large shiny "books" of cookeite.

9.5 Turn west off Rodney Parham Road onto Hinson Road.

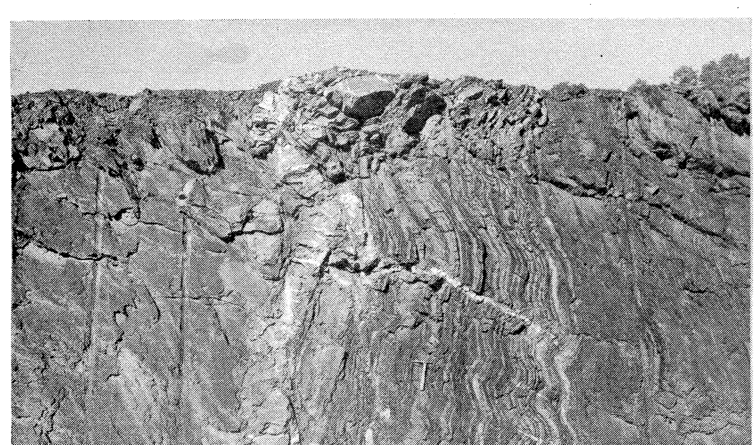
Faulted Jackfork sandstone and shale with numerous sedimentary slide features, along west wall of Interstate Highway 430 road-cut on south flank of Big Rock Syncline - Stop 1-1.



Close-up of previous picture showing northward dipping fault and cleavage planes, and inter-bedded relationships of the Jackfork - Stop 1-1.



Very thin, graded sandstone (light) and shale (gray) beds. Notice minute crinkling of strata and milky quartz veins dipping northward along cleavage surfaces - Stop 1-1.



9.9 Turn south off Hinson Road onto Napa Valley drive.

10.9 Shale, siltstone and discontinuous, blocks of sandstone in the middle Jackfork Formation near the axis of the Shinall Mountain syncline. Small quartz veins with crystals and some cookeite fill fractures in the sandstone.

11.0 Turn east off Napa Valley drive onto Mara Lynn Road.

11.1 Discontinuous, broken middle Jackfork sandstone on left.

11.3 Maroon shale and lenticular sandstone of the middle Jackfork on left.

11.9 Turn south off Mara Lynn Road onto Shackleford Road.

12.1 Lower and middle Jackfork shale and discontinuous sandstone on left. All rocks dip to north in this belt, as does the cleavage. From which direction are the tectonic forces?

12.2 Turn west off Shackleford Road onto W. Markham Street.

12.3 Sheared shale of lower and middle Jackfork to north.

12.9 Turn south off Markham Street onto Bowman Road.

13.1 Lenticular, massive sandstone and maroon shale of the lower and middle Jackfork.

13.6 Junction of Bowman and Kanis Roads - continue south on Bowman.

14.0 Faulted and sheared lower Jackfork shale and sandstone with quartz veins.

14.2 A minor small flint concretionary mass was noted here in the lower Jackfork shale and thin sandstone.

14.5 Bridge on Panther Creek. Low dipping (northward) Panther Creek thrust fault zone separating the lower and middle Jackfork of the Frontal Belt from the Stanley Formation, or in places the Arkansas Novaculite of the northern "core" of the Ouachita Mountains.

14.6 Sheared, northward-dipping shale with minor sandstone and quartz veins of the lower Stanley Shale.

14.9 Thin slices of faulted and intensely folded Arkansas Novaculite and lower Stanley Shale are present in this area.

15.1 Broken, sheared, northward dipping sandstone and shale of the lower Stanley Shale. Quartz veins containing cookeite dissect the sequence. The cleavage dips 28° to the north and the hinge line of the strongly reclined folds rakes 87° to the north, fold rotations are clockwise.

15.25 Junction of Bowman Road and 36th Street. Continue south on Bowman Road.

15.45 Brodie Creek Bridge. Cleavage attitude here is 38° to the north.

15.5 Faulted and highly-cleaved Arkansas Novaculite and lower Stanley Shale.

15.8 Contact between the Ordovician upper Womble and Bigfork Formations in intensely faulted area. Typical upper Womble graptolites have been collected near this locality.

16.0 Turn west off Bowman Road onto Colonel Glenn Road (renamed after American astronaut).

16.2 Turn south off Colonel Glenn Road onto Lawson Road. Stay on Lawson Road. Lawson Road is reported to be near a route that DeSoto traveled during his trek through Arkansas in 1541. Upper Womble shale, phosphatic sandstone, and minor dense gray limestone are exposed in the area.

16.35 Junction Lawson - David O. Dodd Roads. Continue right on Lawson. The cleavage dips 17° to the north-northeast and the hinge line of the recumbent fold dips 3° to the north-northwest; fold rotations are clockwise.

16.9 Highly cleaved, northward-dipping upper Womble shale. Ridge composed of phosphatic sandstone of upper Womble to right. The sandstone interval is very thin on south side of antiformal structure.

17.4 Passing through east-west ridge of Bigfork Chert and valley formed by Polk Creek Shale and Missouri Mountain Shale.

17.55 Fairly massive, light gray, partially recrystallized, intensely sheared, Lower Division Arkansas Novaculite exposed on right. The old Pulaski County road metal quarry to east.

18.2 STOP 1-2. (20 MINUTES) PULASKI COUNTY - ARKANSAS NOVACULITE QUARRY.

Pulaski County road metal quarry in novaculite, chert and siliceous shale of the Lower, Middle and Upper Divisions of the Arkansas Novaculite. Notice severe northward-dipping shears and fault planes related to recumbent folds which reflect a southward direction of tectonic transport. Minor quartz veins of Late Paleozoic age are present along some fracture systems. Manganese and iron oxides coat some surfaces. A spectacular weathered alkalic dike (Late Cretaceous) occurs at west end of pit.

Stop 1-2 on the south side of Ellis Mountain provides good examples of varying fold trends in the Lower Paleozoic strata of the eastern Ouachitas. There are two major trends. One, named the Alexander trend, consists of inclined folds, having nearly horizontal hinge lines. These folds are upfacing, consistently overturned toward the south or southwest, and they outline the physiographic trends in the Alexander Quadrangle of the Eastern Ouachitas. The other trend, which has been named the Ellis Mountain trend after the fold pattern at Ellis Mountain, is also inclined toward the southwest, but the fold hinges are reclined. The folds at Stop 1-2 belong with the Alexander trend; the Z rotation, on the geological map for this stop, belongs with the Ellis Mountain trend. The cleavage is believed to be associated with the Ellis Mountain folding.

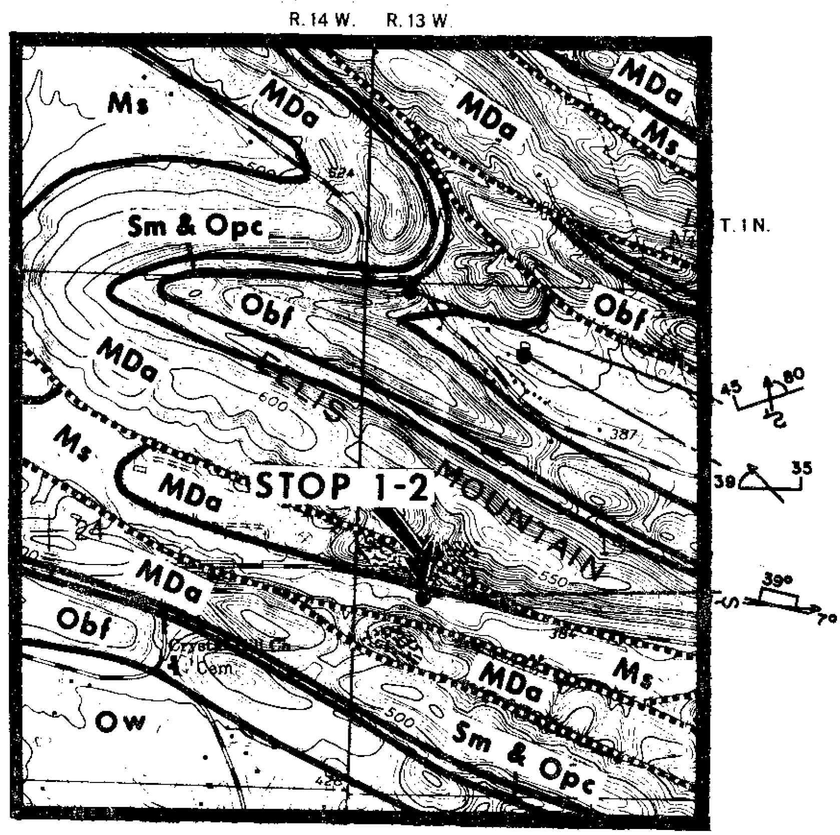
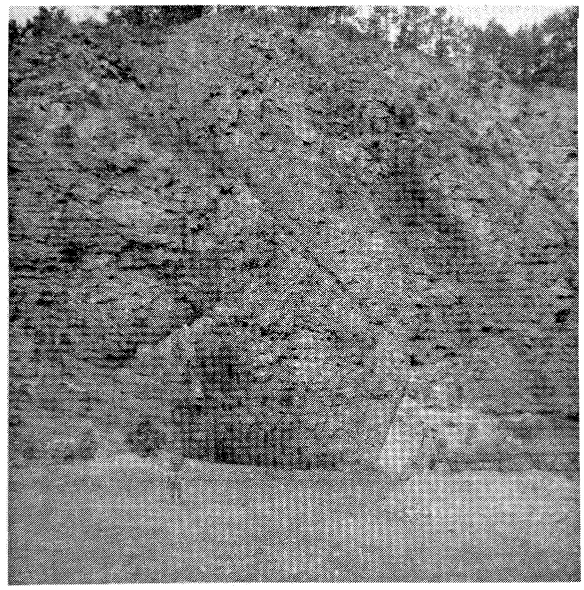


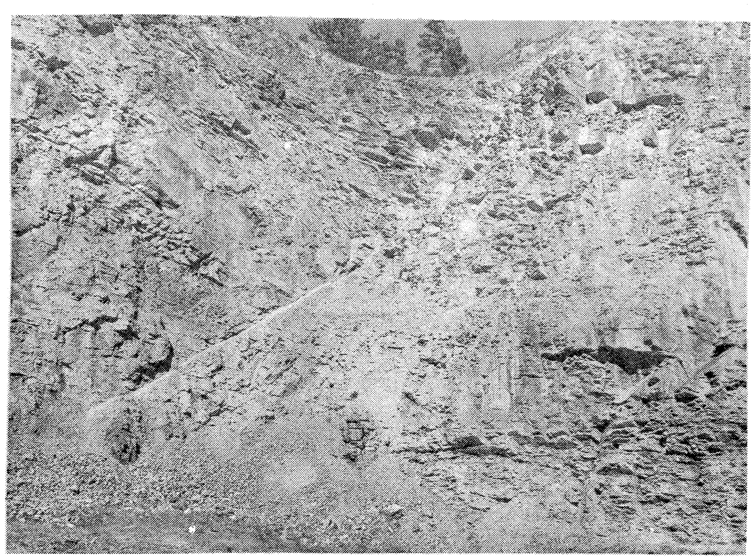
PLATE 2. GEOLOGIC MAP OF ELLIS MOUNTAIN AREA- STOP 1-2.

1000 0 1000 2000 3000 FEET

Geology by Stone Haley and Sterling



Large overturned synclinal fold with northward dipping fault in Arkansas Novaculite. Notice decomposed alkalic dike in lower right corner of photograph - Stop 1-2.



Intensely folded and sheared Arkansas Novaculite, with light colored altered, alkalic dike in west wall of Pulaski County quarry - Stop 1-2.

18.4 Continue west on Lawson Road.

18.8 For the next 0.2 miles the route traverses poorly exposed Stanley Shale, Arkansas Novaculite, Missouri Mountain Shale, Polk Creek Shale, Bigfork Chert, into the upper Womble Shale.

19.0 Junction - stay on Lawson Road.

19.3 Rubble from large milky quartz vein to north. The veins occur along a large northeastward-dipping fault zone. Bedding dips are also consistently to the northeast. Some small exposures of "talcose" shales and quartzitic sandstones with some meta-arkose or granite boulders of the Blakely Sandstone occur locally in area to southeast.

20.8 Turn north off Lawson Road onto Marsh Road.

20.9 Weathered exposures of faulted and sheared Womble Shale with numerous milky quartz veins.

21.0 Thin-bedded cherts and siliceous shales of the Bigfork Chert. A northward dipping fault occurs in the narrow valley formed by the Polk Creek and Missouri Mountain Shales.

21.1 This exposure of Arkansas Novaculite is intensely folded, sheared, and faulted. The section begins with somewhat tripolitic, massive Lower Division and proceeds to thin cherts and black siliceous shales of the Middle Division and then to thin-bedded novaculite and chert of the Upper Division of the Arkansas Novaculite; then to gray slate, siliceous shale and poorly sorted siltstone of the lower Stanley Shale.

22.0 Northward-dipping lower Stanley shale and thin graywacke.

22.2 Turn west off Marsh Road onto Colonel Glenn Road and proceed on the lower Stanley Shale on the north flank of a tightly southward verging syncline.

22.8 Turn north off Colonel Glenn Road onto Burlingame Road.

22.9 - 23.25 Intensely folded and cleaved lower Stanley Shale, Upper, Middle and Lower Divisions of Arkansas Novaculite, Missouri Mountain Shale, Polk Creek Shale, Bigfork Chert and upper Womble Shale.

An abundant, rather typical Middle Ordovician graptolite fauna occurs in the upper Womble shale at this locality (23.25). They were initially collected and examined by L. S. Griswold and R. R. Gurley (Ark. Surv. Vol. II, 1890).

A complete study and reevaluation is needed on graptolites in the Ouachita Mountains, particularly in light of recent mapping.

Generally poor exposures of the Womble Shale for next 12.6 miles. The lower, rather humpy, ridges to north and south are Bigfork Chert; and the higher ridges are Lower Division of the Arkansas Novaculite.

25.2 Exposure of graptolite-bearing upper Womble shale, both cleavage and bedding dip to the north.

26.9 Turn west off Burlingame onto Kanis Road. Some nice clear quartz crystals were obtained in 1965 from the Gordon prospect in the faulted Womble Shale on small hill to north. Also some milky quartz from this general region has been mined commercially for exposed aggregate in precast concrete slabs.

27.8 Ante-bellum home to south (left).

28.25 Ferndale, Arkansas. Junction of Kanis and Ferndale cutoff road. Continue west on Kanis Road. (See first day supplementary road log Ferndale, Arkansas to Warner Soapstone Pit - p. 49).

28.75 Bridge over Little Maumelle Creek with southward overturned upper Womble Shale.

28.95	Exposure of cleaved Womble Shale to north. Bigfork Chert and Arkansas Novaculite form ridges on complex synclinal structures both to north and south. In this area the axial plane dips 35° and the hinge line rakes 67° to the north-northwest; fold rotations are counter-clockwise.
29.95	Exposure of tightly-folded and cleaved upper Womble Shale to north (right).
30.75	Power line with view of Bigfork Chert and Arkansas Novaculite ridges to north and south. In this area the cleavage dips 29° north-northeast; fold rotations are counter-clockwise.
32.65	To the south is a gravity fed water main from Lake Winona, a significant Little Rock water supply.
33.85	Large milky quartz vein in a northward dipping fault zone in upper Womble Shale. In this area the axial plane dips to the north and the hinge line of the fold dips 23° to the northeast; fold rotations are clockwise.
34.85	Exposure of intensely-cleaved Womble Shale to south.
35.55	An intensely cleaved Womble Shale exposure to south.
35.8	Contact between Womble Shale and Bigfork Chert to west.
35.9	Tightly folded and intensely cleaved Bigfork Chert to north.
36.15	Exposure of highly cleaved Womble Shale to north.
36.35	Public spring issuing from Bigfork Chert to south.
36.9	Graptolite-bearing upper Womble shale and siliceous shale to the east. The Bigfork Chert is nearly removed by faulting in the nose of the anticlinal structure.

GEOLOGIC SECTION
Sedimentary Rocks

Age		Rock Unit		Maximum Thickness (feet)	Map Symbol
Holocene		Alluvium		20	Qal
Pleistocene		Terrace		40	Qt
Cretaceous		Brownstown		40	Kb
Pennsylvanian		Atoka Formation	Upper	4,000	IPau
			Middle	5,500	IPam
			Lower	18,000	IPal
		Johns Valley Shale		1,500	IPjv
		Jackfork Sandstone		6,000	IPj
Mississippian		Stanley Shale	Chickasaw Creek	8,500	Ms
			Hatton Tuff		
			Hot Springs Sandstone		
Devonian		Arkansas Novaculite	Upper Division	950	MDa
			Middle Division		
			Lower Division		
Silurian		Missouri Mountain Shale		250	Smm
		Blaylock Sandstone		1,500	Sb
Ordovician	Late	Polk Creek Shale		175	Opc
	Middle	Bigfork Chert		800	Obf
		Womble Shale		3,500	Ow
	Early	Blakely Sandstone		400	Oby
		Mazarn Shale		3,000	Om
		Crystal Mountain Sandstone		850	Ocm
		Collier Shale		1,000+	Oc

Igneous Rocks

Age	Rock Type	Map Symbol
Pennsylvanian or older	Soapstone-Serpentine Intrusive	IPi
Cretaceous	Alkalic Dikes and Igneous Breccia	Ki

36.95	Valley formed by Polk Creek Shale and Missouri Mountain Shale.
37.0	Crossing through Lower, Middle, and Upper Divisions of Arkansas Novaculite (locally probable Hot Springs Sandstone) and lower Stanley Shale. Sponge spicules have been noted from thin novaculite beds at the top of the Upper Division of the Arkansas Novaculite in this area.
37.6	Fresh black lower Stanley slate exposed to south.
38.1	This major thrust fault is nearly horizontal. Arkansas Novaculite is exposed on small ridge south of creek. Northward dipping, massive, broken and discontinuous, rather clean sandstone of the lower and middle Jackfork Sandstone crop out on road to north. Rectorite occurs in quartz veins dissecting the massive sandstones.
38.4	Highly sheared and multiply folded shale of the lower Stanley Shale to north. The fold axes generally plunge northeastward.
38.9 - 40.7	Excellent exposures of sheared and multiply folded lower (?) Stanley Shale on both sides of road.
41.1	Crossing north fork of Saline River.
41.45	Paron, Arkansas. Turn west off Kanis onto road by North Fork Missionary Baptist Church.
41.5	Turn south off road onto Ark. Hwy. 9. Alluvial material in this area covers faulted lower Stanley Shale.
41.6	Cross bridge over branch of north fork of Saline River.
41.8	STOP 1-3. (25 MINUTES) WINDOWS, KLIPPEN AND REFOLDED STRATA OF NORTHERN "CORE".

Near the bridge a major fault separates the covered lower Stanley Shale from the Bigfork Chert which is exposed to the south. The cherts, and siliceous

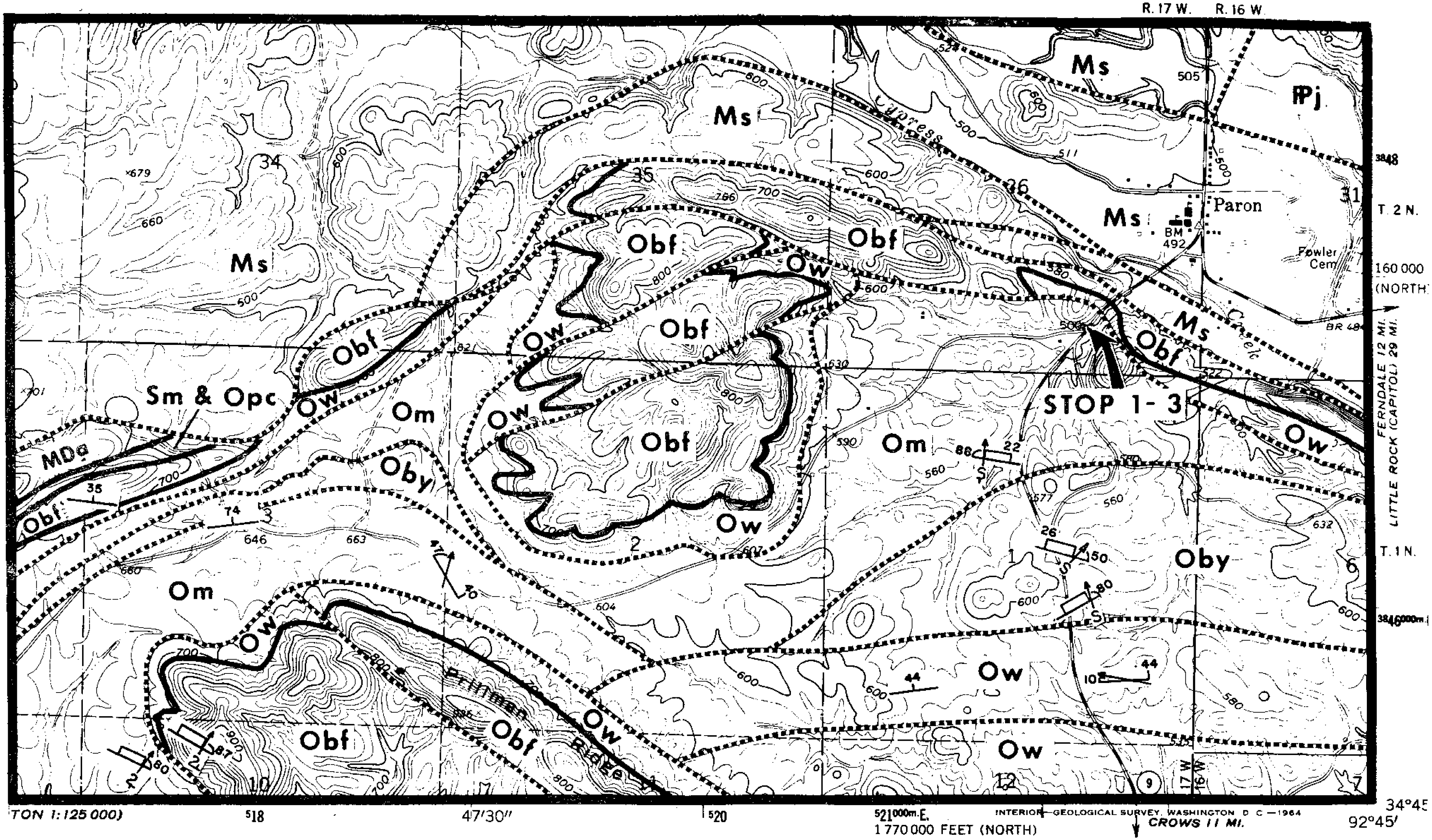


PLATE 3. GEOLOGIC MAP OF PARON, ARKANSAS AND VICINITY-STOP 1-3.

1000 0 1000 2000 3000 FEET

Geology by Haley and Stone

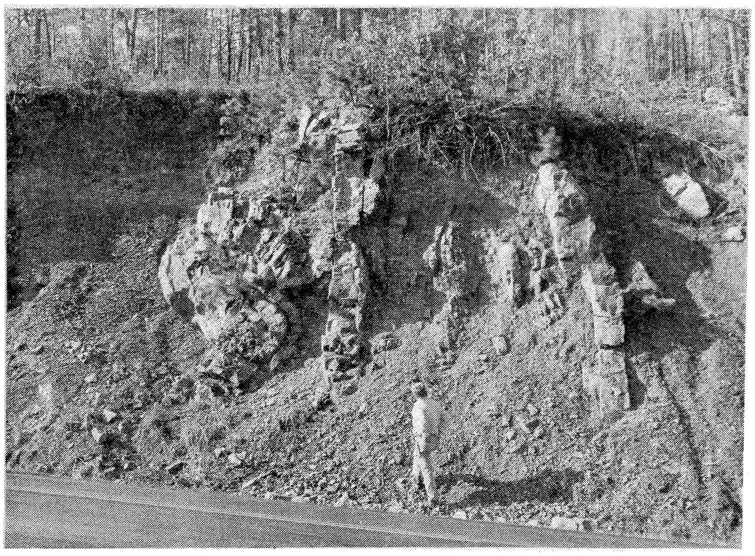
limestones of the Bigfork are intensely sheared. Traces of petroliferous minerals were noted in quartz-calcite veinlets cutting the unit. Thin, dense, gray limestone and shale of the upper Womble Shale are next exposed. Subsequently, along the north side (notice abundant cedar trees) the trace of a large, low angle, folded fault plane (thin white gouge zone) which separates the Womble from banded slate, limestone and siltstone of the Mazarn Shale. A significant graptolite fauna occurs in some of the banded slates of the Mazarn. Several periods of horizontal-to-steeply plunging folds; intense northward dipping cleavage; large milky quartz veins; and weathered Late Cretaceous lamprophyric dikes are features that may be seen in this area.

The structure in this area is complex and it goes without saying that interpretations may change. First, along Highway 9, the map trends indicate east-west or northwest-southeast striking beds. Dips are consistently to the north and the succession of the formations as a whole indicates a stratigraphic section younging northward. Axial surfaces and cleavages are moderately inclined and dip north, but fold hinges are consistently of high rake; the folds are either raking folds or reclined folds.

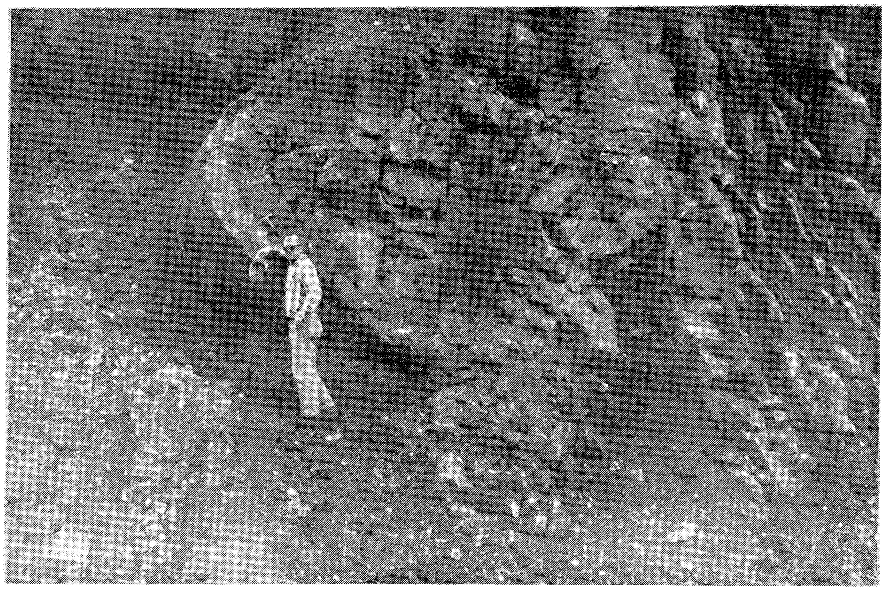
Toward the west, in an area unfortunately inaccessible to buses there are two isolated areas of Bigfork Chert and Womble Shale lying across the Mazarn Shale. As they cannot be connected to any nearby outcrops of Bigfork, they do not appear to be the result of cross folding but are more probably klippen. Viele thinks they may be part of the nappe composing the Ellis Mountain-Ferndale trend. On the west side of the southernmost klippe, recumbent, isoclinal folds having northward rotations are backfolded to Z patterns when viewed down plunge. Z folds on the lower limbs are accented; S folds on the upper limbs are damped.

These relations along the highway and at the klippen suggest superposed folding, a northward direction of tectonic transport followed by backfolding to the south.

42.0	Turn around and proceed north on Ark. Hwy. 9.
42.5	Paron, Arkansas.
43.0	North fork of Saline River.
43.25	Alluvial terrace covering sheared northward-dipping shales of Stanley Shale to east.
44.25	Quartz veins in faulted graywacke-to-fairly-clean-sandstone and shale, in the middle Stanley Shale to east.
45.05	Folded and faulted shale and sandstone of the middle Stanley Shale. Numerous quartz veins containing clay and mica minerals dissect the strata.
45.15	Browns Corner. Lake Winona is about 6 miles west on Saline County road.
45.35 - 45.45	Crossing large northward-dipping (?) fault zone separating middle Stanley Shale possibly of the "core area" from lower and middle Jackfork Sandstone of the frontal belt of the Ouachita Mountains.
46.25 - 46.95	Faulted, often overturned, shale and small sandstone lenses or pods of middle Jackfork Sandstone.
47.05	Covered large thrust fault zone in middle Jackfork Sandstone.
47.45	Faulted, sheared, southward overturned, rather clean, bottom marked, sandstone and black shale of middle Jackfork Sandstone. Small slickenside zones contain abundant dickite and minor quartz veins. Some complexity in structure is undoubtedly related to submarine slumping during and after deposition.
47.65	Small, weathered, northeast trending Late Cretaceous lamprophyric dike cutting vertically through Jackfork shales to east.



A complex southward verging fold with bottom of bed to right (north) in middle Jackfork sandstone and shale on the west side of Arkansas Highway 9 at mileage 48.0.



Close-up of overturned fold at mileage 48.0--the information suggests that the massive quartzitic sandstone buckled while the less resistant shale sheared and flowed during tectonic processes.

47.85 Perry County Line. Faulted middle Jackfork Sandstone to west.

48.0 On west nearly vertical (bottom to north), alternating sandstones and shales of middle Jackfork Sandstone. Notice excellent small fold, which is overturned to south and is related to small fault zone containing abundant dickite. Several small quartz veins contain cookeite (a lithium chlorite) and rectorite (alternating layers of montmorillonite and pyrophyllite).

48.05 Disturbed, northward dipping shales in middle Jackfork Sandstone to west.

48.55 Nearly vertical (bottom to north), faulted and folded lenticular sandstone and shale in middle Jackfork Sandstone.

49.0 Discontinuous sandstone masses in shale near the middle Jackfork Sandstone.

49.3 STOP 1-4. (15 MINUTES) BASAL UPPER JACKFORK SANDSTONE.

On west side of road, nearly vertical dipping basal upper Jackfork sandstone and interbedded shale. This deep-water sequence has numerous bottom marks (bottom to north), graded and convolute bedding, and lenticular sandstone masses. Several high-angle faults dip steeply to the north and apparently have been thrusted towards the south. Slickensides with dickite are common along the breaks. Steep northward dipping cleavage and shearing are well-developed in the shales. Small sandstone beds have boudinage features. There are apparently three generations of veins (1) An earlier folded and cleaved network containing very thin pyrophyllite, (2) large milky quartz with dickite, and, (3) some small later milky quartz with rectorite and locally containing cookeite and pyrophyllite.

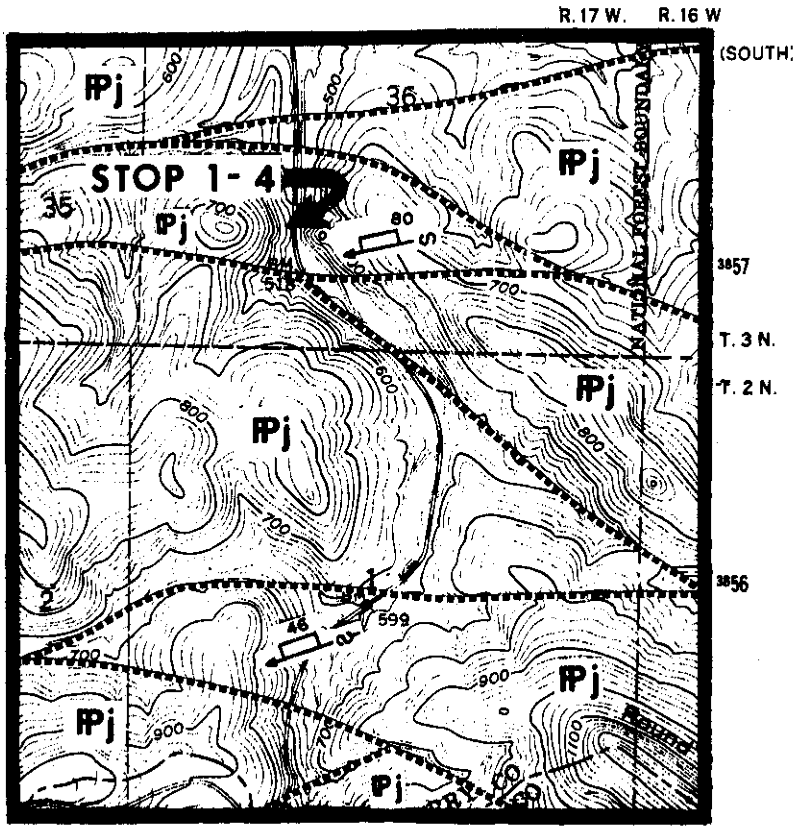


PLATE 4. GEOLOGIC MAP ALONG ARKANSAS HIGHWAY 9, NEAR WILLIAMS JUNCTION- STOP 1-4.

1000 0 1000 2000 3000 FEET

Geology by Stone and Haley

Notice the difficulty in correlating strata across the road to exposure with small cave cut by previous stream erosion.

Stop 1-4 lies in a zone Viele has referred to as the Maumelle chaotic zone, taking the name from structurally complex exposures of sandstone and shale along the south side of Lake Maumelle. These exposures have been the subject of much discussion among Haley, Stone, Viele, and others, quite a bit of it pretty noisy. What is at issue here is the relative dating of sedimentary slumping and structural deformation. Does the chaos of sandstone and shale, which composes some of the Jackfork along this trend, represent sliding from the north from submarine scarps, normal faults, etc. into the geosyncline or does it represent sliding from the south off the backs of northward-advancing nappes? Was Carboniferous sedimentation essentially completed before the time of intense compressional structural deformation or were sedimentation, sliding and compressional structural deformation synchronous?

49.9 Highly sheared (towards north) black shale and small sandstone lumps in the upper Jackfork Sandstone.

50.05 Northward sheared and dipping gray-black shale and quartzitic sandstone of upper Jackfork Sandstone. Quartz veins containing rectorite occur near north end of exposure.

50.25 Bridge over Big Maumelle River.

50.7 Junction Ark. Hwys. 9 and 10. Proceed north on Hwy. 10. Large thrust fault separating Jackfork Sandstone from probable Johns Valley Shale occurs beneath the alluvium.

50.9 Shale and siltstone of probable Johns Valley Shale dips to north.

51.2 Disturbed sequence of probable Johns Valley Shale, with thin siltstones and some small, oxidized iron carbonate concretions.

51.65 Bridge over Big Maumelle River.

52.1 Concealed fault thrusting probable Johns Valley Shale northward over alternating subgraywacke sandstone and gray shale in the lower portions of the lower Atoka Formation.

52.35 The thick, flysch deposited lower unit of the Atoka Formation is exposed for about the next 5 miles. Northward dipping shale and sandstone in lower part of lower Atoka Formation to west.

52.5 Bridge over Maumelle Creek.

52.6 Northward dipping alternating shale, siltstone and sandstone near the middle of the lower Atoka Formation.

53.85 Thornburg, Arkansas. In this area the Thornburg syncline and Wye anticline, and related faults, are somewhat complex "large wrinkles" developed in the lower Atoka Formation on the south flank of a large syncline.

54.75 Steep, northward dipping, alternating shale, siltstone and sandstone of the middle portions of the lower Atoka Formation.

56.15 Steeply inclined shale, siltstone and sandstone in upper part of lower Atoka Formation.

56.55 Trace of Fourche LaFave fault which thrusts the upper part of the lower Atoka Formation northward over shale of the middle Atoka Formation.

56.95 Junction of Ark. Hwys. 10 and 216, continue north on Hwy. 10. The probable late Cretaceous Brazil Branch lamprophyric breccia occurs about one mile to the west. Some fragments of possible Precambrian granite have been identified in the rock (Croneis, 1930).

57.55 Southward-dipping shale, siltstone and flaggy sandstone of the "traceable three" sequence in the upper portions of the middle Atoka Formation.

57.7 Harris Brake Lake, a Game and Fish Commission impoundment to the east. Approximate axis of the Fourche LaFave - Perryville syncline developed in the middle Atoka Formation.

58.3 Junction of Ark. Hwys. 10 and 300, continue north on Hwy. 10.

59.3 Bridge over Fourche LaFave River.

59.8 Perryville, Arkansas, continue north on Ark. Hwy. 10.

60.5 Contact between steeply southward dipping shale of the middle Atoka and the sandstone and shale of the lower Atoka Formation.

60.7 - 60.8 Perryville igneous breccia (vein dike) of probable Late Cretaceous age is exposed to east especially at pit near housetrailer and is composed mostly of angular to subangular sedimentary rock fragments and altered chloritic material. Lamprophyric fragments occur in a nearby mass. Undoubtedly, igneous materials occur at depth in the breccia.

61.2 - 61.9 STOP 1-5. (30 MINUTES) PERRYVILLE SECTION - LOWER ATOKA.

Begin walk downhill through exposure to mileage 62.6. Be careful - considerable traffic on road. This is an excellent exposure exemplifying flysch deposition with monotonous repetitions of interbedded thick-to-thin, southward dipping, graded, bottom marked, convolute bedded subgraywacke; very micaceous, siltstone containing coalified plant fragments; and black fissile shale with some sideritic iron concretions near the middle of the lower Atoka Formation. Probable deep-water trace fossils are numerous in the sequence. Some small dickite-coated slickensides and minute quartz veins are present locally. This is a portion of the 10,000 foot sequence measured by Croneis in 1929 and placed in the Atoka Formation. We now know the

R. 17 W.

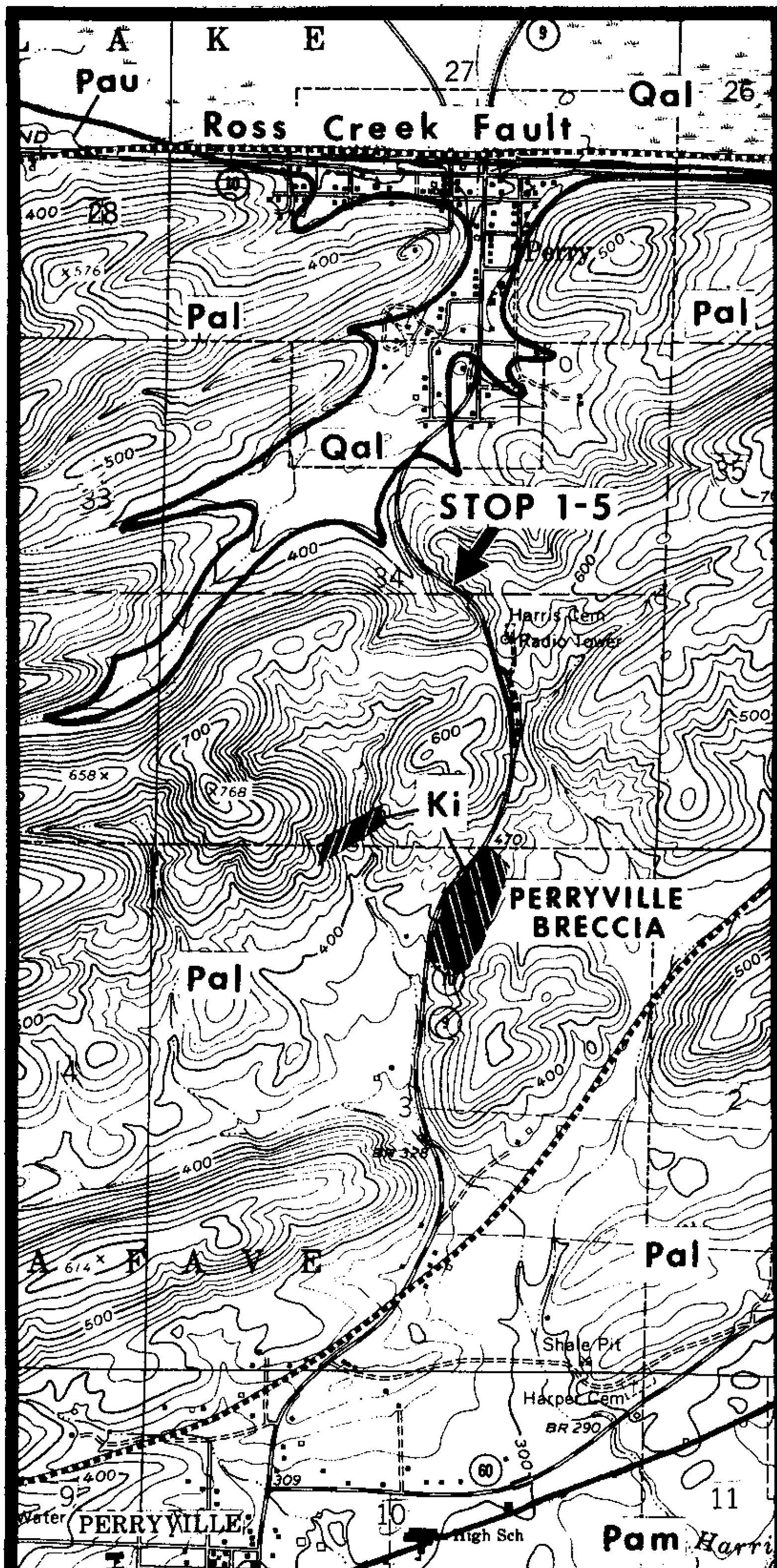


PLATE 5. GEOLOGIC MAP OF PERRY-PERRYVILLE, ARKANSAS-STOP 1-5.

1000 0 1000 2000 3000 FEET

Geology by Stone

section is an incomplete lower Atoka interval. The total Atoka thickness is about 20,000 feet in this area. Some of the basal lower Atoka is probably Late Morrowan in age. Near the railroad tracks at Perry, Arkansas some 0.5 miles to the north the Ross Creek? fault has thrust lower Atoka on the south flank of the Casa-Redemption anticline northward over upper Atoka units. The stratigraphic displacement is over 10,000 feet.

Turn around and proceed south on Ark. Hwy. 10.

64.7 Turn west off Ark. Hwy. 10, onto Ark. Hwy. 60.

65.5 Southward dipping shale in lower part of middle Atoka Formation

73.6 Catfish farm to south. You are on or near the contact between middle and lower Atoka Formation up to mileage 81.1.

74.8 Aplin, Arkansas.

75.3 Junction of Ark. Hwys. 60 and 155, continue west on Hwy. 60. Colluvial cobbles and southward-dipping shales of the middle Atoka Formation.

76.1 Terrace deposit to north contains mostly rounded lower Atoka sandstone cobbles, but there are some pebbles of chert likely derived from Johns Valley Shale or from Stanley Shale to the west or southwest.

76.5 Southward-dipping, ripple marked, uppermost sandstone unit in lower Atoka Formation.

78.0 Steeply-dipping sandstone at top of lower Atoka Formation. Locally near base it contains quartz and chert granules with some widely scattered fragments of crinoids and brachiopods.

79.7 Shale near base of middle Atoka Formation to north.

80.4 Nimrod, Arkansas.

81.1 Southward-dipping shale and sandstone near base of middle Atoka Formation to north.

82.2 Shale near base of middle Atoka Formation to north.

82.5 A concealed thrust fault occurs in this area.

83.4 Faulted shale and sandstone near top of lower Atoka Formation to north.

84.3 Junction of Ark. Hwys. 60 and 7 at Fourche Junction, continue west on Hwy. 60. Exposure of highly faulted sandstone near top of lower Atoka Formation.

84.4 Turn south off Ark. Hwy. 60 onto road leading to Nimrod Dam.

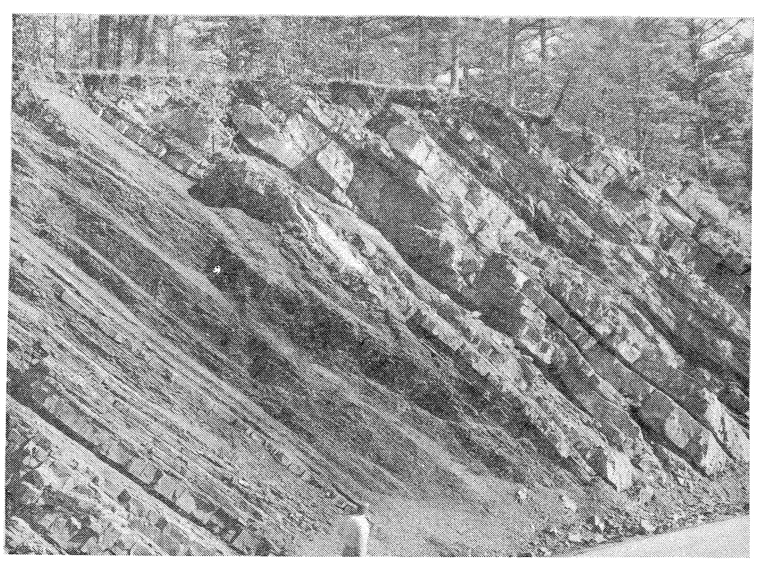
84.5 Middle Atoka shale, and overthrusted siltstone, and sandstone of lower Atoka Formation.

85.1 <u>STOP 1-6. (15 MINUTES) NIMROD DAM-OVERLOOK AND FAULT ZONE (ALSO REST STOP!)</u>

Sandstone near top of lower Atoka thrust in a series of imbricate slices northward over middle Atoka shale along the Fourche LaFave River fault zone. Rather abundant white dickite and some slickensides occur in some zones. Large submarine sediment flow and slide features are suggested by some sandstone surfaces. Traces of clear to milky drusy quartz along some fractured sandstone surfaces.

Folds at Nimrod Dam appear to be typical "Valley and Ridge" type folds. Most are inclined toward the north and have horizontal axes. They are associated with south-dipping imbricate thrust faults and are probably floored by a flat-lying regional decollement. Tectonic transport was toward the north. However, as Highway 7 is followed toward the south, another set of folds appears with increasing frequency. These folds are inclined toward the southeast and have hinges

Close-up of lower Atoka sandstone, siltstone and shale, with examples of convolute bedding and localized soft sediment slump and sliding - Stop 1-5.



Alternating sandstone and shale of the lower Atoka, an example of flysch. Perryville Section - Stop 1-5.

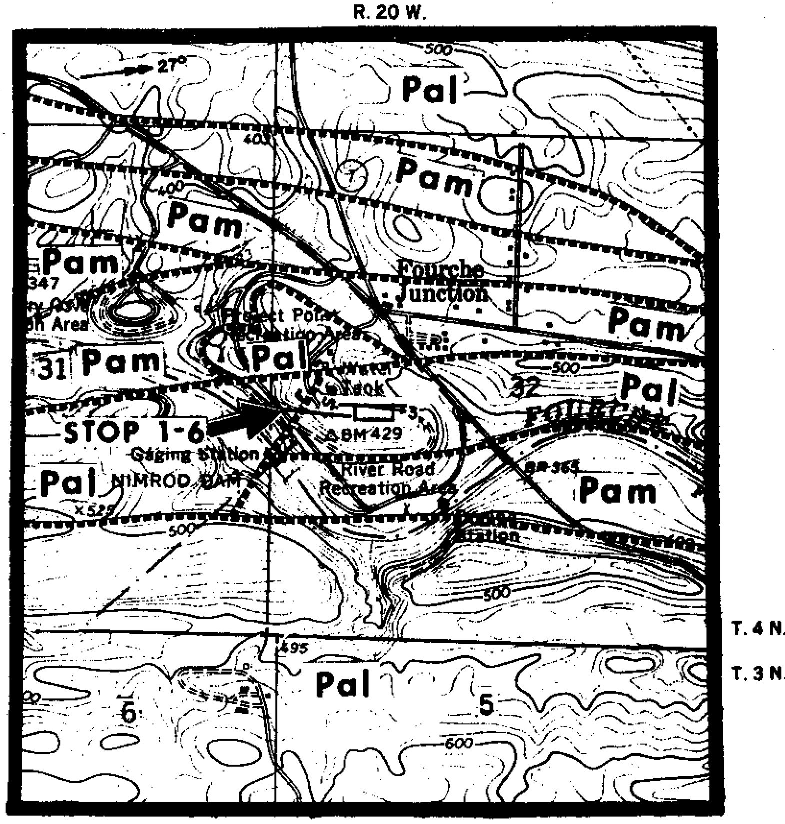


PLATE 6. GEOLOGIC MAP OF NIMROD DAM- STOP 1-6.

1000 0 1000 2000 3000 FEET

Geology by Stone and Haley

raking toward the northeast. They exhibit southeastward rotations and are strongly cleaved. As they seem quite distinct from the folds of the Frontal Belt, they are tentatively assigned to a later Hot Springs trend.

Continue down-river into park.

85.3 Turn left at stop sign in park.

85.7 Turn south onto Ark. Hwy. 7. Generally northward-dipping sandstone, siltstone and shale (flysch facies) of the lower Atoka Formation for next 8.0 miles.

85.8 Bridge over Fourche LaFave River.

85.9 A severely faulted sequence in the hanging wall of the Fourche LaFave thrust plate.

86.1 Shale, siltstone and sandstone in upper part of lower Atoka Formation.

88.2 Several small faults near middle of lower Atoka Formation.

89.1 Abundant bottom marks (flute, prod, load, etc.), graded bedding and other flysch features on northward dipping sandstone near middle of the lower Atoka Formation.

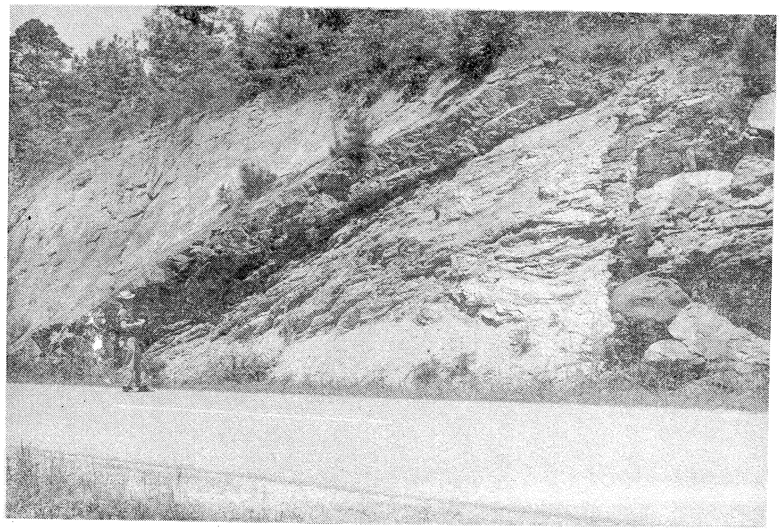
90.2 Bridge over Little Cove Creek.

90.5 Steeply northward dipping, alternating sandstone, siltstone and shale.

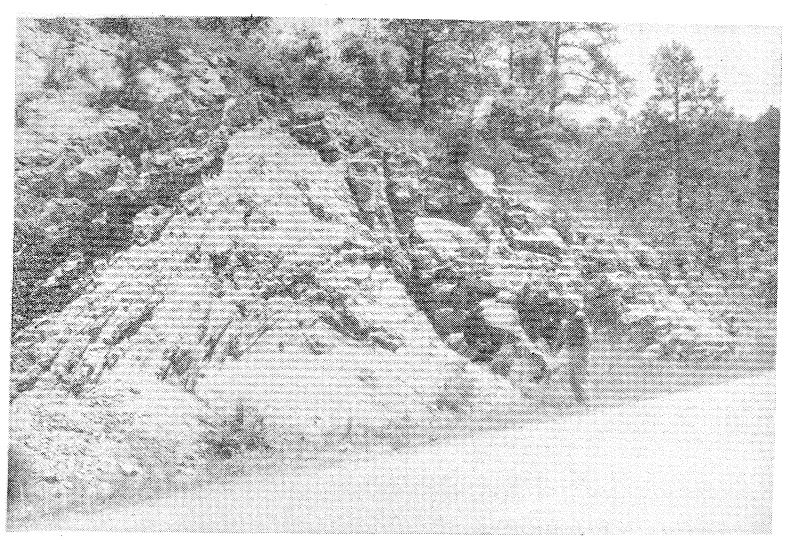
91.3 - 93.0 Several very small folds and faults in lower portions of lower Atoka Formation.

93.7 Upright lower Atoka sandstone and shale to west. View of Forked Mountain to south, an upper Jackfork Sandstone pinnacle.

94.7 Large fault thrusting Johns Valley Shale northward over the lower Atoka Formation.



Small faulted anticlinal structure in sandstone and shale near top of lower Atoka on Arkansas Highway 60, northwest of Nimrod Dam (Stop 1-6).



Close-up of previous picture, but looking to the northeast down the axis of the fold. Notice southward dipping fault trace separating massive sandstone from the siltstone and shale.

95.3 STOP 1-7. (15 MINUTES) TYPICALLY CHAOTIC JOHNS VALLEY SHALE.

Mostly clay shale of the Johns Valley Shale, with small discontinuous sandstone lenses and iron concretions. Small faults are numerous and the slickensides are coated with dickite. Small folds are present and appear to be both structural and sedimentary in origin. Ridges to the east and south are fault slices of various portions of the Jackfork Sandstone thrust generally northward over the Johns Valley Shale.

About 8.5 miles to the west on the north side of Ark. Hwy. 314 in the SE¼ SE¼ sec. 31, T. 3N., R. 21W., the Johns Valley Shale contains a discontinuous mass of limy sandstone with Morrowan fossils (Mackenzie Gordon, written communication). Limestones, including erratic masses; however, are far less common here in the Johns Valley in comparison with areas farther to the west in the frontal Ouachita Mountains.

Continue south on Ark. Hwy. 7.

95.4 Crossing Magie Creek and low-angle fault trace. Note southward overturned fold in probable upper Jackfork Sandstone to north (left). The sandstone contains some impressions of the fossil plant Lepidodendron.

96.0 Massive, steeply-dipping upper (?) Jackfork Sandstone to the east and north have been thrust over the Johns Valley Shale.

96.2 Downtown Hollis, Arkansas. Very intense thrust faulting occurs in this belt of the frontal Ouachita Mountains and has been called by some the "Maumelle Chaotic Zone" and the "Y" City fault by others.

96.3 Spectacular cliff formed by vertical sandstone and shale of the upper Jackfork Sandstone to the east.

96.5 Bridge over South Fork of Fourche LaFave River.

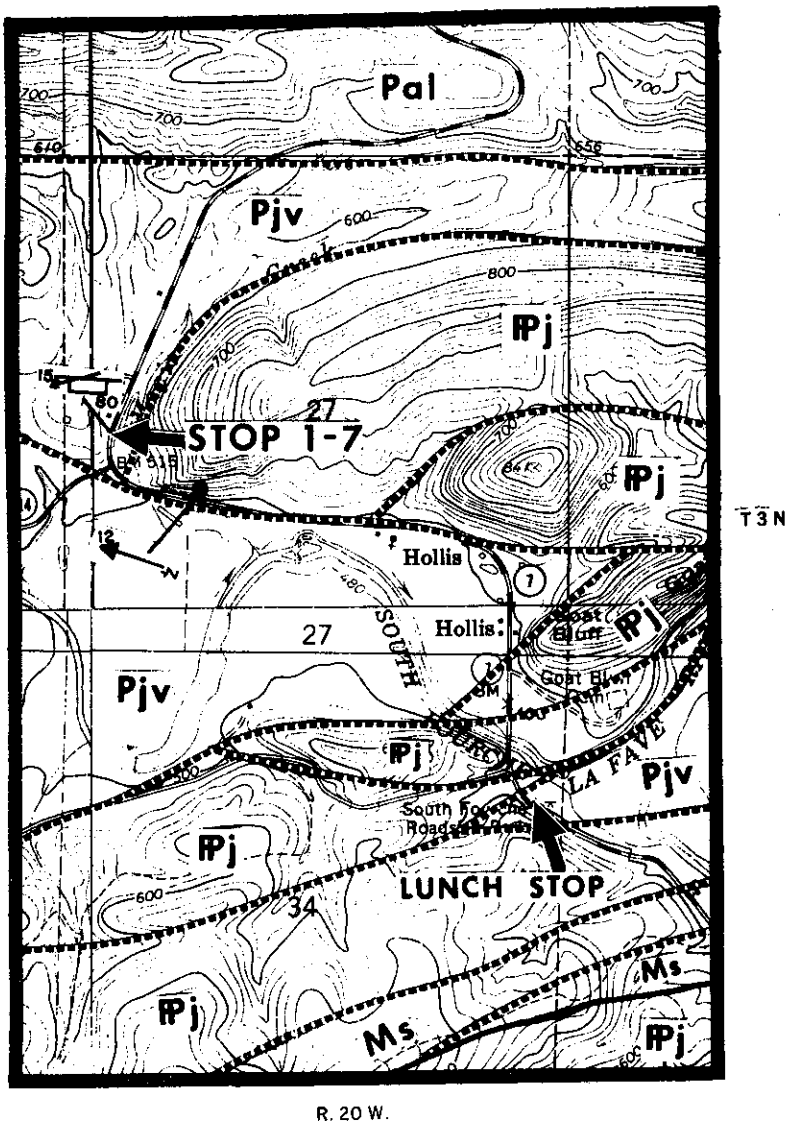


PLATE 7. GEOLOGIC MAP OF HOLLIS, ARKANSAS- STOP 1-7.

1000 0 1000 2000 3000 FEET

Geology by Stone and Haley

Complex warped structure in shale and siltstone of the Johns Valley Shale probably created by a combination of tectonic and sedimentary slide phenomena - Stop 1-7.

Massive, vertically dipping, faulted (part of a klippen??) Jackfork Sandstone on the east side of Arkansas Highway 7 at mileage 96.3, Hollis, Arkansas.

96.6 Intensely folded and faulted sandstone and shale of the Jackfork Sandstone with abundant dickite along many slickenside surfaces. Traces of rectorite occur in quartz veins dissecting the hard sandstone.

96.65 Possible Lunch Stop at Picnic Area to east. Good exposure of faulted Johns Valley Shale to west.

97.0 Steeply dipping faulted, sandstone and shale of probable Johns Valley Shale to west. Some faulted middle Jackfork Sandstone a short distance to south.

97.4 Sam and Ann's Restaurant - eat lunch here if you have a chance! Faulted upper Stanley shale and chert to west up dirt trail about 0.4 miles.

98.65 STOP 1-8. (15 MINUTES) DISCONTINUOUS SANDSTONE MASSES IN MIDDLE JACKFORK SANDSTONE.

Northward dipping shale and small, lenticular sandstone beds and lumps in the middle Jackfork Sandstone. This is an excellent example of sediment flowage or pull-apart.

98.75 Bridge over Bear Creek. Indeed black bears have been recently re-stocked in the area. A major fault occurs at approximately this position.

99.45 Former site of Hollis CCC (1935-1941) camp to west.

99.55 Steeply dipping, intensely folded and faulted sandstone and shale of the middle Jackfork Sandstone Some excellent sediment flow features. Quartz veins are numerous and contain rectorite and some needle quartz crystals.

101.05 Bridge over Sugar Creek with exposures of middle Jackfork shale and discontinuous sandstone to east.

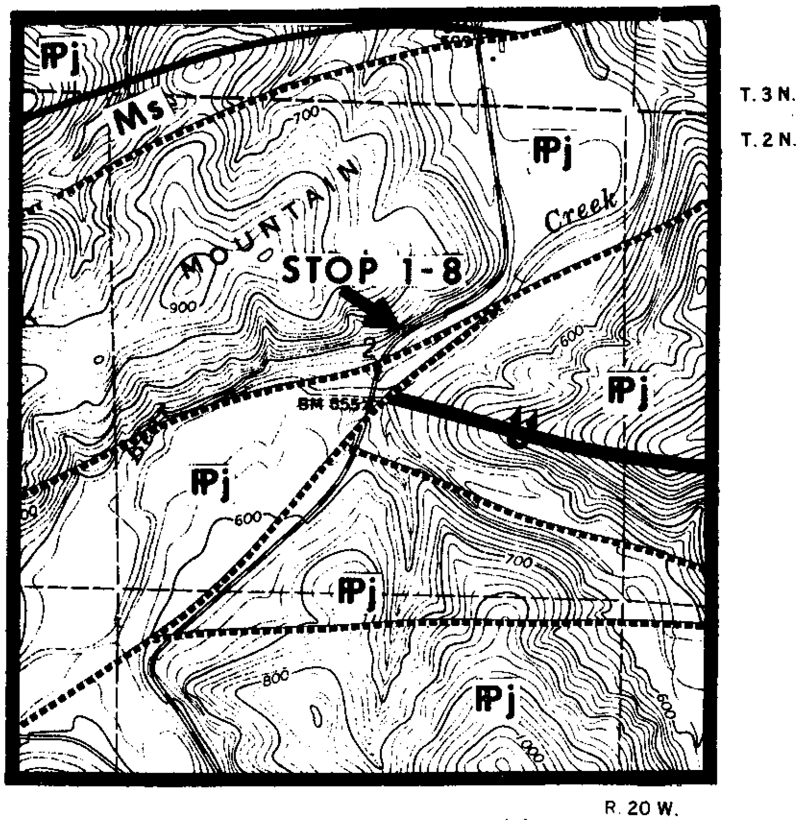
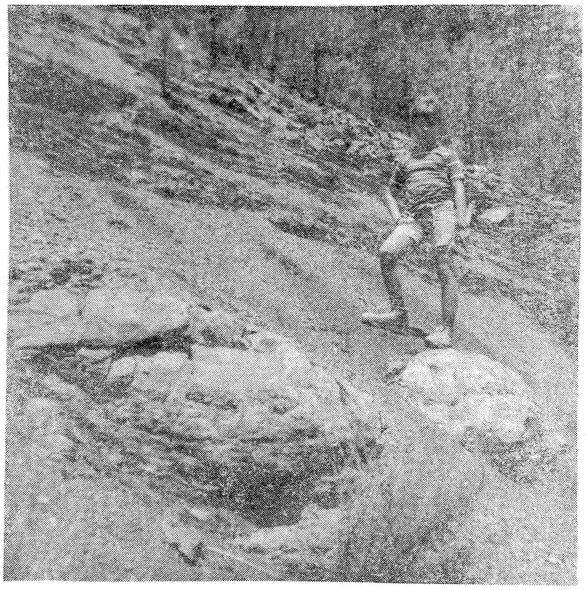


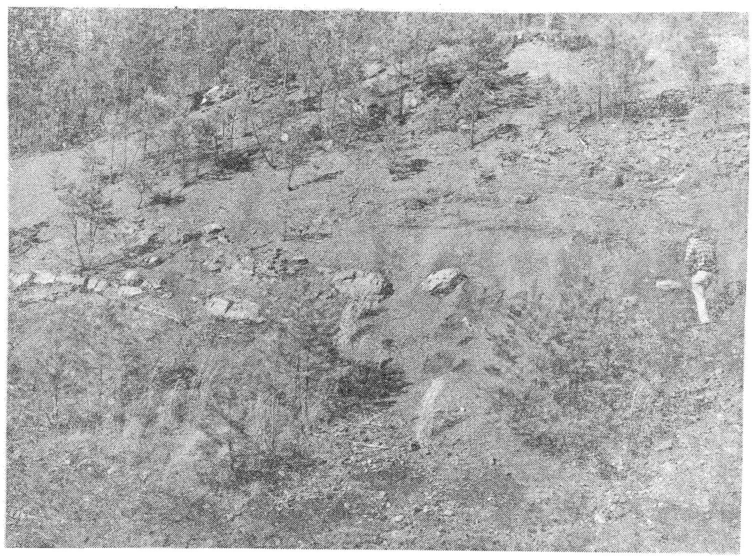
PLATE 8. GEOLOGIC MAP OF BEAR CREEK AREA-STOP 1-8.

1000 0 1000 2000 3000 FEET

Geology by Haley and Stone



Close-up of small sandstone boulders with apparent bottom marks on all visible sides - Stop 1-8.



Sandstone masses in black shale of the middle Jackfork. Excellent examples of transformation from bedded sandstone to "boulders". Stop 1-8.

101.8 Shale with siderite concretions in lower Jackfork Sandstone.

102.55 Northward-dipping contact of massive, fairly clean, sandstone of the lower Jackfork Sandstone and shale and subgraywacke of the upper Stanley Shale. Thin beds of siliceous shale, "holey" chert and "biscuit rock" siderite concretions occur here in the shales of the Chickasaw Creek Member of the upper Stanley. Some fracture-filling quartz veins of Late Paleozoic age contain needle quartz crystals and traces of rectorite.

103.35 Shale, siltstone and sandstone of the upper Stanley Formation.

103.75 Siderite concretions, some of which contain cone-in-cone and milky quartz veins with olive green chlorite occur in faulted middle Stanley Shale.

104.75 Sheared shale and graywacke of the middle Stanley Shale. Significant thrust faulting occurs in this area.

105.45 Trace of large fault thrusting middle Stanley Shale southward over middle Jackfork Sandstone.

105.75 Steeply-dipping, massive sandstone of the middle Jackfork Sandstone to west at bridge.

105.85 Garland County line.

106.05 Folded, thin-bedded sandstone and shale of the middle Jackfork Sandstone to the west.

106.55 Old Jessieville CCC (1935-1941) camp to east.

106.75 Folded and faulted northward dipping, lower Jackfork shale and sandstone. Quartz veins contain abundant rectorite and needle quartz crystals. Good bottom marks and graded bedding occur on some thin sandstone beds. Minor sediment-flow and pull-apart features are present.

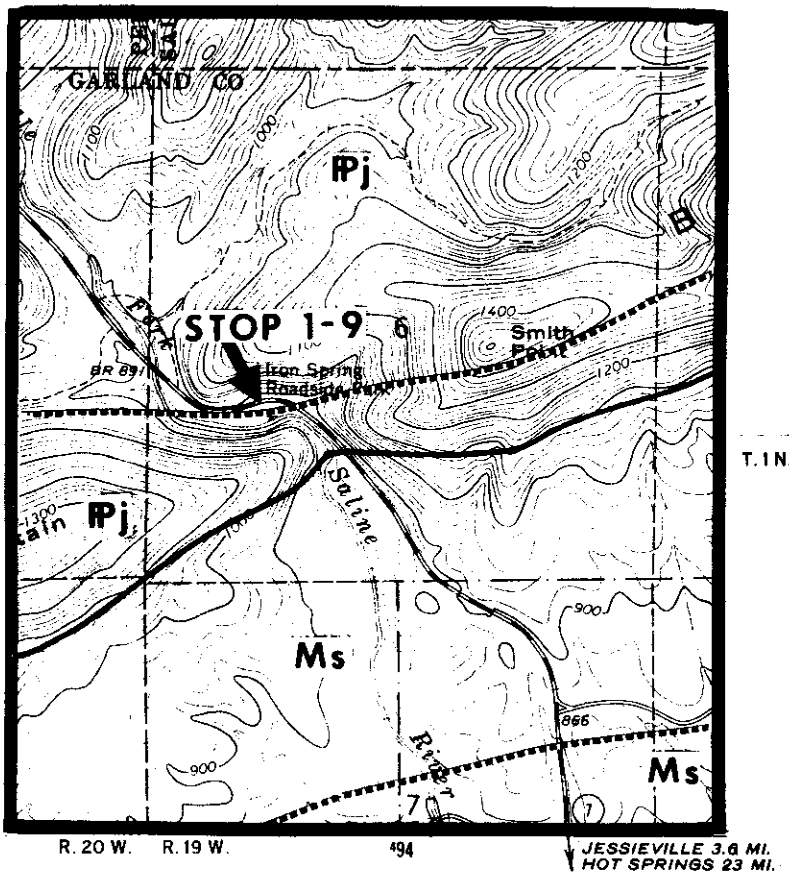


PLATE 9. GEOLOGIC MAP OF IRON SPRINGS RECREATION AREA-STOP 1-9.

1000 0 1000 2000 3000 FEET

Geology by Stone and Haley

106.85 STOP 1-9. (20 MINUTES) LOWER JACKFORK AND UPPER STANLEY SHALE AT IRON SPRINGS RECREATION AREA.

This is an opportunity to rest a spell; to drink the cool well water; to walk along the small stream; to inspect the excellent exposures of massive to thin-bedded lower Jackfork sandstone, and quartz veins with rectorite at mileage 106.75 or to examine the basal massive Jackfork sandstone and upper Stanley shale, siliceous shale, small concretions and subgraywacke at mileage 107.15.

107.15 Northward dipping interbedded massive quartzitic sandstone and shale of the basal Jackfork Sandstone and "slate", siliceous shale and subgraywacke of the upper Stanley Shale (Chickasaw Creek Member). Small "biscuit rock" iron concretions, holey chert fragments, and locally a thin chert-siltstone conglomerate typify the upper portions of the Stanley; Pitkin Formation boulders and other erratics have been identified in this unit near Forked Mountain east of Hollis (Gordon and Stone, 1968).

107.35 - 108.65 Generally northward dipping and sheared intensely faulted shale and graywacke of the middle and lower Stanley Shale. Some siliceous shale and cone-in-cone siderite and chert concretions are also present. Small milky quartz veins are numerous in the area, and have been mined locally for crystals (Engel, 1954). These veins are especially common in the larger fault zones.

109.35 - 109.45 STOP 1-10. (20 MINUTES) BIGFORK CHERT IN THE NORTHERN "CORE" OF OUACHITA MOUNTAINS.

This generally vertical dipping strata is an intensely crinkled and cleaved sequence of thin-bedded chert and siliceous shale of the Bigfork Chert. Some crinoid impressions were noted locally in the unit. Small hills to north and south poorly expose rather thin-bedded chert, novaculite, siliceous shale and conglomeratic sandstone or chert of the Arkansas Novaculite. The small draws between the Bigfork and Arkansas Novaculite are underlain by the Polk Creek Shale and the Missouri Mountain Shale, which typically are shale or slate, but in this area contain some thin chert, novaculite, sandstone, and conglomerate beds.

By the time Stop 1-10 is reached, the Hot Springs fold trend has become dominant. Strongly-cleaved folds are inclined southward, and hinges rake toward the northeast. Variations in attitude of the axial surfaces of the Hot Springs trend are ascribed to a third period of deformation, the Benton uplift, which broadly arched the entire folded belt.

In this area, bedding attitudes, the sequence of formations, and the fold rotations, initially suggested to Viele an upright stratigraphic section and folds downfacing toward the north. Further work established that the Stanley was overturned and apparently backfolded to the south over the novaculite. Moreover, the mapping showed that all fold rotations, viewed down plunge, were the same, notwithstanding their position on opposing limbs of a fold. Therefore, they must be later features that were superposed on an older fold.

Continue south on Ark. Hwy. 7.

110.15 Bridge over Middle Fork Creek. Highly-cleaved and folded novaculite-sandstone conglomerate of the Arkansas Novaculite in creek bed to west.

110.25 An excellent exposure of highly-folded, northerly trending and cleaved banded slate and limy siltstone of the Mazarn Shale to the west. A major folded, low-angle fault occurs between Middle Fork Creek and this locality. Milky quartz veins are

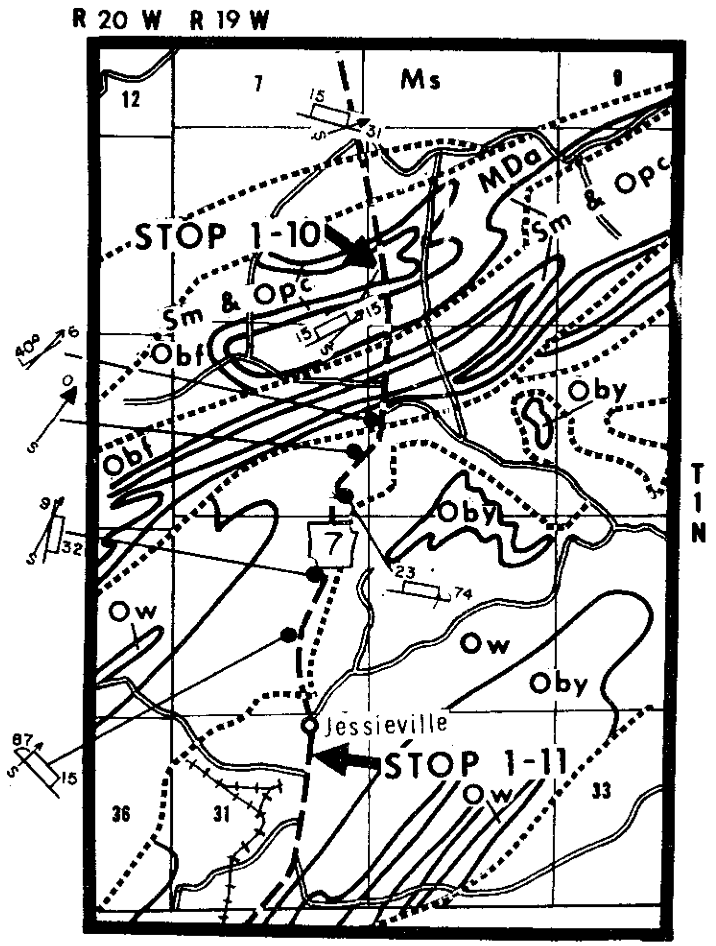


PLATE 10. GEOLOGIC MAP OF JESSIEVILLE, ARKANSAS AND VICINITY-STOPS 1-10 AND 11.

1 0 1 2 3 Miles

Geology by Stone and Haley

very abundant throughout this belt (Engel, 1954). Bass and Ferrara in Am. Jour. of Science (1969) found that adularia crystals from the Hamilton-Hill--Teal quartz crystal mine five miles to the east had isotopic ages of between 214 and 287 m.y. (Late Pennsylvanian-Middle Permian or later).

111.65 Sheared shale and calcareous siltstone of the Womble Shale faulted northward onto Mazarn Shale in exposure to east. Notice "talcose" nature of shale and numerous milky quartz veins.

111.7 City limits of Jessieville, Arkansas.

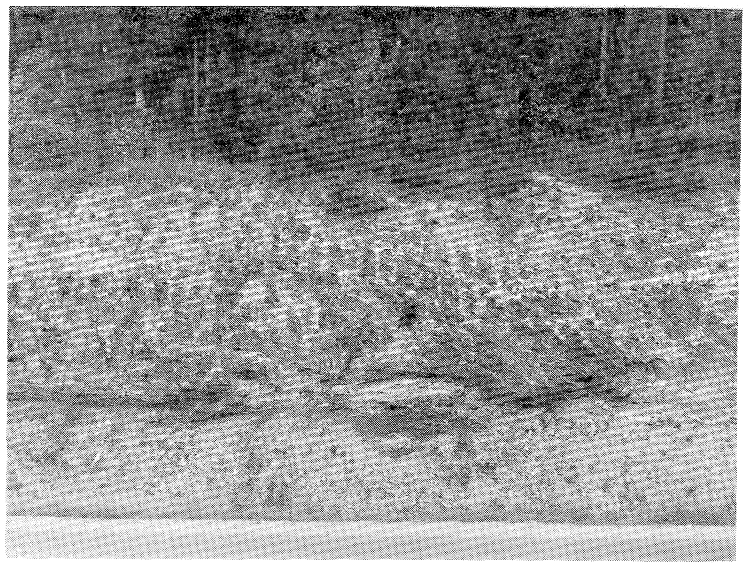
111.85 Jessieville High School to east rests on intensely-folded Womble Shale.

111.05 STOP 1-11. (15 MINUTES) RECUMBENT FOLDS AND LOW-ANGLE FAULTS IN WOMBLE SHALE.

This is an excellent example of recumbent folds and associated faults in shale and thin-bedded decalcified siltstone of the Womble Shale. Notice once again the numerous milky quartz veins. Critical observations at the exposure include the top and bottom of beds, cleavage-versus-bedding in the shales, thickening ratio of beds into axial hinges of folds, and possibly the direction for the translation of the tectonic forces.

112.45 Junction of Ark. Hwys. 7 and 298, continue south on Hwy. 7.

112.55 - 112.65 Alternating massive-to-thin, quartzitic to very calcareous sandstone and gray, maroon to buff shale and shaly siltstone of the Blakely Sandstone. Along south end of cut pebbles of meta-arkose or granite and other types occur in a five-foot calcareous sandstone bed. Notice



A nearly horizontal fault trace and overlying recumbent fold in Womble shale and weathered limy siltstone at Jessieville, Arkansas - Stop 1-11.

fracture-filling milky quartz veins. Several quartz crystal mines are located in cavities in the Blakely Sandstone in this area.

112.85 STOP 1-12. (20 MINUTES) COLEMAN'S ROCK SHOP.

This is an opportunity to acquire some of the excellent, locally mined, quartz crystals. Turn to west onto gravel road at Coleman's Shop.

112.95 Intensely-folded shale and limestone of the Mazarn Shale to the south.

114.35 Turn north onto dirt road to Coleman's Quartz Mine, previously described as the West Chance area, Dierks No. 4 Mine, Blocher Lead (Engel, 1951, U.S.G.S. Bull. 973-E.)

114.65 STOP 1-13. (25 MINUTES) COLEMAN'S QUARTZ MINE - BLAKELY SANDSTONE.

Highly weathered, very limy, massive to thin beds of sandstone and clay shale of the Blakely Sandstone on the nose of a large plunging syncline. One or more zones, varying from a few to many feet in thickness, contain swarms of weathered meta-arkose and granitic pebbles, cobbles and boulders (as large as 45 feet in diameter). Most of the feldspar-quartz material is coarsely crystalline, but some is silt sized. The source is postulated from submarine slides derived from Precambrian or Cambrian exposures along scarps originally north of the depositional site. The weathered nature of this rock lends itself nicely to prospecting for large quartz crystal cavities which are often located near the intersection of two veins. A significant quantity of large, clear quartz crystals has been produced from this area in recent years. Some oscillator quality quartz was obtained by the Federal Government from the area during World War II.

The geological map for Stops 1-13 and 1-14 shows two zones of cross folding, one west and one north

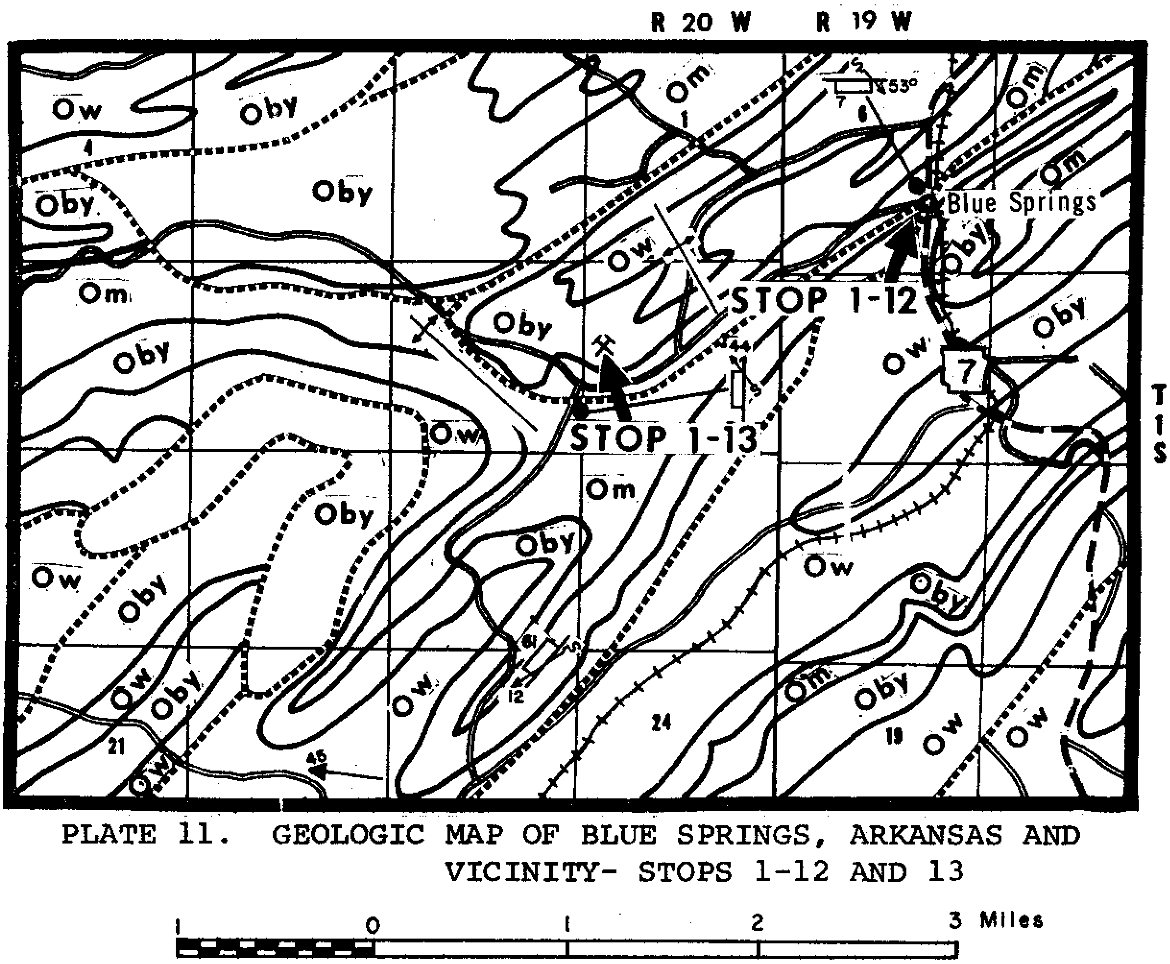


PLATE 11. GEOLOGIC MAP OF BLUE SPRINGS, ARKANSAS AND VICINITY- STOPS 1-12 AND 13

Geology by Haley and Stone

Weathered Blakely (limy) Sandstone with various granite, meta-arkose, and limy arkosic siltstone erratics, with dissecting milky quartz veins at Coleman's Quartz Mine - Stop 1-13.

Rounded to angular, light-colored, granite-meta-arkose pebble melange in limy sandstone matrix of the Blakely - Stop 1-13.

of the stop. Note too, the variation in attitude of the fold hinges and axial planes. The Hot Springs trend is dominant, but what was the pattern of the earlier folding?

Return out access road.

114.95 Turn west (right) onto gravel road.

115.25 Black sheared, "talcose" (illitic) shale, thin flint intervals and dense, massive-to-flaggy, sometimes sandy, limestone of the Mazarn Shale in creek bed on both sides or road.

115.35 Turn south (left) at Junction onto Weyerhaeuser Road.

115.45 "Talcose" appearing, sheared shale and flint of the Mazarn Shale.

116.55 Intensely folded and cleaved, banded shale, thin siltstone and thin-to-massive sandstone of the Blakely Sandstone.

116.75 Highly cleaved shale and calcareous siltstone of the lower Womble Shale.

116.95 Tightly-folded shale and sandstone, with some patches of flint in the Blakely Sandstone. Rattlesnakes are rather numerous throughout this region!

117.35 - 117.75 Exposure of banded Mazarn shale to west.

117.8 Small pit with southward inclined folds in Blakely Sandstone.

117.85 Rubble from Blakely Sandstone to west (right).

118.05 Turn west onto paved Weyerhaeuser Road. Highly folded shale, dense limestone, calcareous siltstone and some sandstone of the lower Womble Shale for next 2 miles.

118.25	Exposure of brown, punky, decalcified siltstone of the Womble Shale to right.
120.75	Turn south onto Ark. Hwy. 227.
121.15	Exposure of Blakely sandstone and shale on north flank of large anticline.
121.35	Banded Mazarn shale to east (left).
121.4	Typical exposure of Blakely sandstone and shale. About one mile to east is a large quarry in lower Womble limestone, used for riprap at Blakely Mountain Dam.
121.85	Contact of upper Womble shale and thin interbedded limestone, siliceous shale, and chert of the Bigfork Chert. The typically highly-fractured Bigfork Chert is regarded as the most reliable aquifer in the Ouachita Mountains.
122.75	Severely folded Bigfork Chert to northwest. Continue in Bigfork exposures for next 0.5 miles. Some clear to white to green wavellite occurs with small milky quartz veins in the area.
123.85	Junction, turn to west (right) on road to Blakely Mountain Dam. Weyerhaeuser road-metal quarry in Bigfork Chert to west. A small weathered lamprophyric dike is exposed in the pit.
124.15	The Weyerhaeuser-Mountain Pine all-purpose sawmill to south.
125.15	Contact between dense limestone and thin shale of the Womble Shale and thin decalcified chert of the Bigfork Chert.
125.75	View of Blakely Mountain Dam and power generator.
126.0	Junction of dam road and spillway road. Turn west (right) on dam road.
126.2	Contact between Womble Shale and Blakely Sandstone.

126.45 STOP 1-14. (30 MINUTES) BLAKELY SANDSTONE AT BLAKELY MOUNTAIN DAM.

A beautiful stop for everyone! Bring cameras!

Buses will pick you up at northeast end of dam.

Interbedded, tightly-folded, cleaved, and faulted, massive sandstone and shale of the Blakely Sandstone. Note excellent sediment-flow features. Also present are granitic-pebble limy sandstone melange, small siltstone dikes, and milky quartz veins with some clear crystals.

Although the Hot Springs trend is dominant in the area of Blakely Mountain Dam, some bottom mark criteria at the Dam and some anomalous directions of fold rotation in the outcrops along the river toward the southeast indicate an older period of folding. At least two sets of cleavage are present. Most folds in the area are inclined toward the southeast; hinges are near horizontal or rake gently northeast or southwest. Note that the clastic dikes parallel to cleavage suggest deformation of soft, water-saturated sediments.

The face of dam is lined with dense, gray, limestone quarried from lower part of Womble Formation in NW, SW, NW, sec. 34, T. 15, R. 22W, northeast of Mountain Pine, Arkansas. Clasts and pelletoidal material occur in some of the beds. John Repetski and Ray Ethington, University of Missouri have made conodont collections from these limestones.

126.65 Return to Mountain Pine, Arkansas and Junction Ark. Hwy. 227 at 129.5.

129.7 Dangerous! A one-way bridge crosses Glazypeau Creek. Notice clear, cold water fed mostly from springs in the Bigfork Chert and Womble Shale (limestone).

130.7 Exposures of the massive Hot Spring Sandstone member of the lower Stanley Shale to east. Some

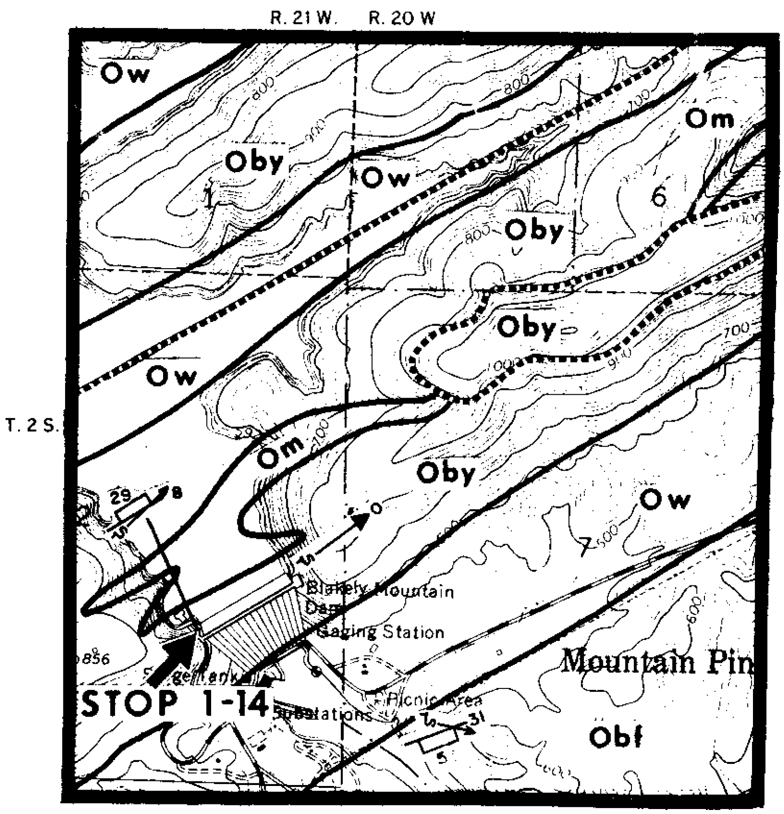
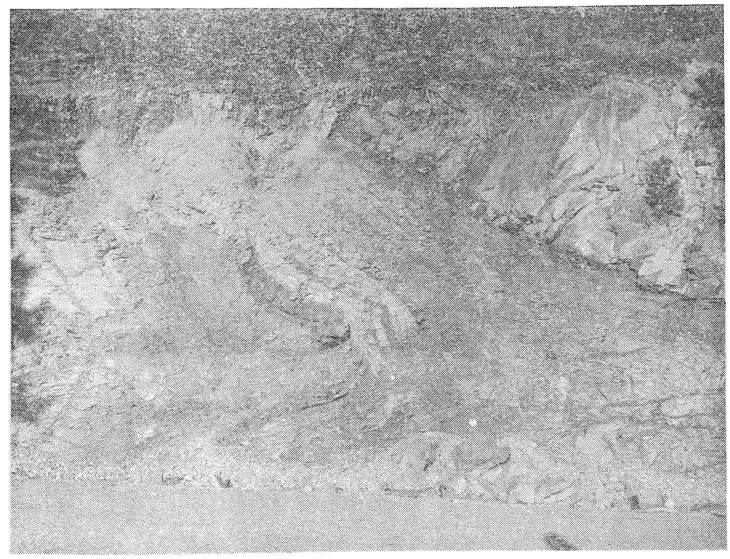


PLATE 12. GEOLOGIC MAP OF MOUNTAIN PINE, ARKANSAS- BLAKELY MOUNTAIN DAM- STOP 1-14.

1000 0 1000 2000 3000 FEET

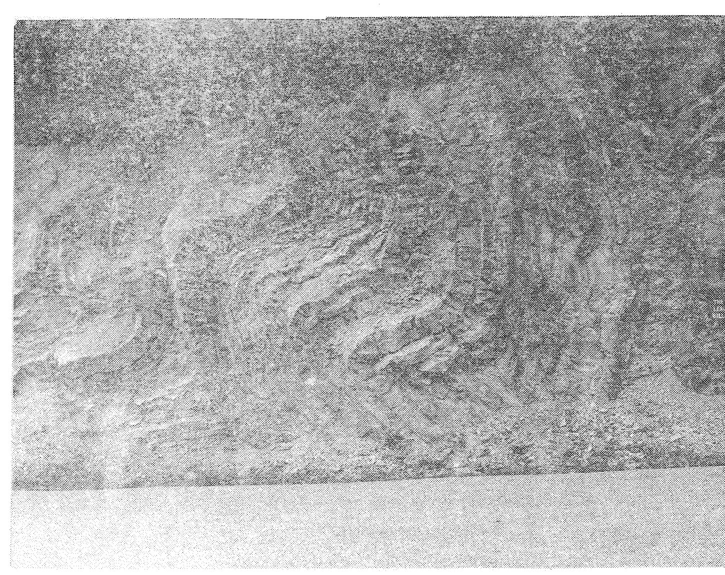
Geology by Haley and Stone

Complex recumbent fold in alternating shale and sandstone of the Blakely at the north end of Blakely Mountain Dam - Stop 1-14.



Another view of fold looking down the northeast trending axis. You should particularly note the horizontal cleavage and the tremendous flowage of the shale - Stop 1-14.

Alternating sandstone and shale with overturned to the left (south) folds in the Blakely at south end of Blakely Mountain Dam - Stop 1-14.



significant thrust faults are present in the area.

133.5 Turn south off Ark. Hwy. 227 onto gravel road. The route is on sheared and folded lower Stanley shale and graywacke to mile 138.4, in a generally overturned (to the south) synclinal area in the Zigzag Mountain subprovince.

135.35 High ridge to south is West Mountain, an anticlinal structure supported by the Arkansas Novaculite.

136.2 Road Junction, continue to east (right) on asphalt road.

136.35 Dangerous! two narrow bridges.

138.4 Turn left (northeast) onto road to pump station at Hot Springs Water Works.

138.95 Take left fork past pump station.

139.05 STOP 1-15. (20 MINUTES) RECUMBENT FOLD AT THE HOT SPRINGS WATER WORKS.

Park at turn-around. Please do not contaminate this area!

Begin walk to north along small lake. (1) Massive upright, southward-dipping, quartzitic sandstone with some thin conglomerate and shale intervals of the Hot Springs Sandstone Member of the Stanley Shale; (2) thin black shale at base of Stanley Shale, (3) thin beds of tripolitic southward-dipping Upper Division of Arkansas Novaculite; (4) then shallow northward-dipping shale, siliceous shale and chert of the Middle Division of Arkansas Novaculite which is intensely folded. This is actually a large recumbent fold which has been transported to the south. Note shallow northward-dipping axial plane cleavage and flowage of shale from flanks into axes of folds. At the small spillway farther to north you can view the Hot Springs Sandstone exposed both above and below the Arkansas Novaculite. A fault truncates the sequence at the upper end of the second small lake.

R. 19 W.

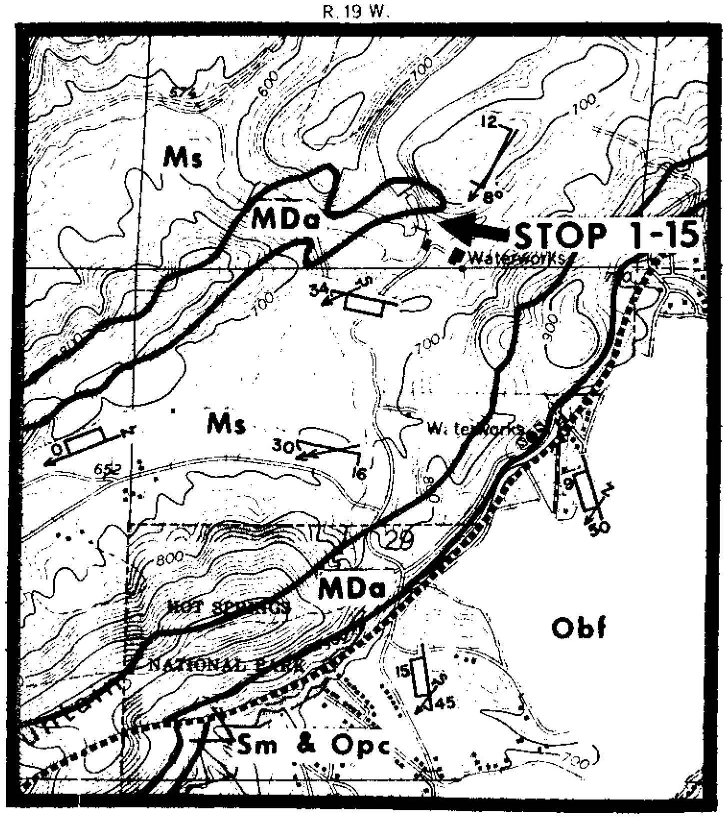


PLATE 13. GEOLOGIC MAP OF NORTHERN HOT SPRINGS, ARKANSAS-STOP 1-15.

1000 0 1000 2000 3000 FEET

Geology by Stone and Haley

139.65 Return to main road and proceed south. For next 0.2 miles you are on the Hot Springs Sandstone Member of the lower Stanley Shale and the Upper, Middle and Lower Divisions of the Arkansas Novaculite on the north flank of a large complex anticline overturned to the south. A thrust fault creates complications in portions of this sequence.

139.85 Turn southeast on side street. You are crossing over a poorly exposed sequence of Missouri Mountain Shale, locally a few feet of thin-bedded Blaylock Sandstone and Polk Creek Shale.

139.95 Turn half-right onto Glade Street.

140.05 Turn half-left on Glade Street.

140.15 The small abandoned rock quarry to the east exhibits rather typical complexly folded (overturned to south) thin-bedded chert, calcareous chert (brown), and siliceous shale of the Bigfork Chert. Note excellent cleavage in more shaly intervals and its refraction across the more massive chert; this has aided the flowage of rock into the axes of the fold. The Bigfork is the most prolific aquifer in the Ouachitas and it also is a source of ready made road metal because of its thin beds and extensive jointing.

We are now in the area of the Zigzag Mountains, which flank the northern margin of the Mazarn synclinorium. Fold hinges trend consistently toward the southwest, but the axial planes exhibit dips ranging from northwest to south. Possibly, a late-stage sinking of the Mazarn synclinorium has warped these surfaces.

Continue south on Glade Street.

140.45 Turn half-right onto Mt. Ida Street.

140.55 Turn right onto Park Avenue (U. S. Hwy. 70B and Ark. Hwy. 7).

140.65 Vapors Supper Club to west, contact of Bigfork Chert and Polk Creek Shale exposed in back of building.

140.75 Northward-dipping, intensely-jointed, massive novaculite of the Lower Division of the Arkansas Novaculite in parking lot to southeast. High quality whetstones or oilstones known as "Arkansas" and "Ouachita" stones are produced locally by several companies from both the Lower and Upper Divisions of the Arkansas Novaculite.

140.85 Turn south at water fountain onto Central Avenue.

141.05 Downtown Hot Springs with view of portions of National Park to east (left).

141.25 Bathhouse row and display hot spring to the east. The U. S. Park Service controls and regulates the use of the water from the hot springs which issue from fractures and joints in the Hot Spring Sandstone along the base and slope of East Mountain. East Mountain is a westward plunging, somewhat faulted, southward overturned anticlinal ridge of the Zigzag Mountain subprovince. Early American Indian tribes, Spanish conquistadors, early settlers and modern man have all exploited the therapeutic properties of the springs. "Tah-ne-co", the place of the hot waters, was the Indian name for the site. About 50 of the original 71 springs produce hot water. According to J. K. Haywood and W. H. Weed (1902) the daily flow aggregates 850,000 gallons with the largest spring yielding a little over 200,000 gallons. The temperature range is from 95.4^{o} to over 147^{o}F. The hot spring water is slightly radioactive, apparently caused by radon gas. A soil-and-vegetation-covered gray calcareous tufa formed by the Hot Springs, covers an area of 20 acres and in places is 6 to 8 feet thick. Measurements of the hot springs flow to the central-collection reservoir have been made periodically since the fall of 1970 by the U. S. Geological Survey. These measurements indicate a range in spring flow of 750,000 to 900,000 gpd with an average flow of about 825,000 gpd. Spring flow fluctuates seasonally.

Several theories have been advanced by Kirk Bryan (1922) and others on the origin of the water, including: (1) Deep fractures and faults tapping hot water given off by cooling igneous rocks, however this is now regarded as unlikely because of the apparent lack of a magnetic anomaly, (typically produced by igneous rocks in the region) and (2) deep fractures and faults tapping water in sedimentary rocks that has been heated by the geothermal gradient.

Actually, there seems to be general agreement on the latter proposal but there is disagreement on location of the water source area, the movement of the water, and depth of heating.

There are currently two general theories on the mechanism of the hot springs. According to one theory the source area for the water is to the east and southeast in the area of the Zigzag Mountains where the Arkansas Novaculite crops out. The water is presumed to move down-plunge through fractures in the Arkansas Novaculite and Hot Springs Sandstone into a deep part of the Mazarn Basin where it is heated to as much as $175^{o}F$. Assuming the average ground water temperature of $65^{o}F$. and a normal geothermal gradient of 1^{o} per 50 feet would require a depth of 5,500 for this increase in temperature. The heated water, because of a lesser specific gravity, and a differential hydrostatic head, then rises along fractures in the Novaculite and the Hot Springs Sandstone to the point of issue at the base of East Mountain.

Proponents of the second theory believe the source area is to the north-northeast in the area where the Bigfork Chert crops out. The water then moves downdip in the Bigfork to a depth where it is heated. The heated water enters the Novaculite and Hot Springs Sandstone either by migration along fault zones through the Polk Creek and Missouri Mountain or through an area where the Novaculite is faulted against Bigfork. The hot water then rises along fractures in the Novaculite and Hot Springs to its points of issue.

141.45	Visitor center Hot Springs National Park to east. Keep right on Central Avenue.
141.95	Junction of Ark. Hwy. 7 and U. S. Hwys. 70 and 270. Turn east onto U. S. Hwy. 70 and continue towards Little Rock. For geologic detail refer to second day road log.
168.45	Junction of U. S. Hwy. 70 and Interstate 30; proceed on I-30 to Little Rock.
196.75	Lease I-30 at 6th Street Overpass.
196.85	Turn west on 6th Street; continue west.
197.75	Turn north on South Gaines Street.
198.75	Sam Peck Hotel, Little Rock, Arkansas.

SUPPLEMENTARY FIRST DAY ROAD LOG

FERNDALE, ARKANSAS, TO WARNER SOAPSTONE PIT

MILEAGE	DESCRIPTION
(28.25)	
0.0	Junction, turn to south (left) at mileage 28.25 of the first day road log onto Ferncliff Road.
0.15	Poor exposure of upper Womble Shale containing some typical Middle Ordovician graptolites. Trail to south leads to an old mine where some very minor quantities of copper were obtained from turquoise veinlets in sheared siliceous shale near the Bigfork-Womble contact.
0.3	STOP 1a-1. BIGFORK CHERT.
	This exposure of northward dipping siliceous shale, chert and punky black siltstone is typical of the Bigfork Chert in this region. Look closely and you will note extremely tight folds overturned to south and related axial plane cleavage. Notice black color of rocks at base of roadcut and light-gray color caused by weathering at the top. Pebble size pyrite concretions occur in some material and green to white turquoise coats a few fractures.
0.4	Valley floored with typically poorly exposed Polk Creek and Missouri Mountain Shale. The Blaylock is either absent in this part of the Ouachita Mountains or is represented by only 1 to 2 feet of very thin siltstone or fine, silty sandstone. Most likely these beds belong to the Missouri Mountain Shale.
0.6	Prominent ridge formed by massive Lower Division of Arkansas Novaculite. A cross fault occurs in

creek to west; thus the novaculite ridges do not exactly match!

0.7 Small spring on east side of road at top of Lower Division of Arkansas Novaculite.

0.8 STOP 1a-2. MIDDLE DIVISION ARKANSAS NOVACULITE.

Can you tell this from the Bigfork Chert at the last stop? Actually there is a little less chert and a little more siliceous shale and shale plus some small pockets of soft, brown, silty sandstone. A good shale sequence normally occurs at the top of the Middle Division.

Notice northward dip of strata, tightness of folds, and axial plane cleavage also dipping to north. Pyrite nodules, crystals and an ozocerite (?) filled cavity have been noted in the siliceous shale. Quartz-pyrite and iron-oxide veins dissect the strata. Note some quartz veins are minutely crinkled by the cleavage. A whitish-green turquoise locally coats some fractures. Finally, some poorly preserved conodonts were noted in the siliceous shales.

0.9 View of Upper Division Arkansas Novaculite ridge to east. Much of this unit is thin, flaggy, novaculite and often is somewhat tripolitic.

1.1 Low-water bridge with poor exposures of Arkansas Novaculite.

1.4 STOP 1a-3. LOWER STANLEY SHALE - TO NORTH FROM BRIDGE.

This is an opportunity to see intensely folded and cleaved shale with traces of siltstone laminae in the lower Stanley Shale. Note the cleavage is rather constant in its dip to the north, but the bedding is quite variable.

In the area shown on Plate 14, folds outlined by the map pattern of the formations belong to the Alexander trend. These folds are inclined toward

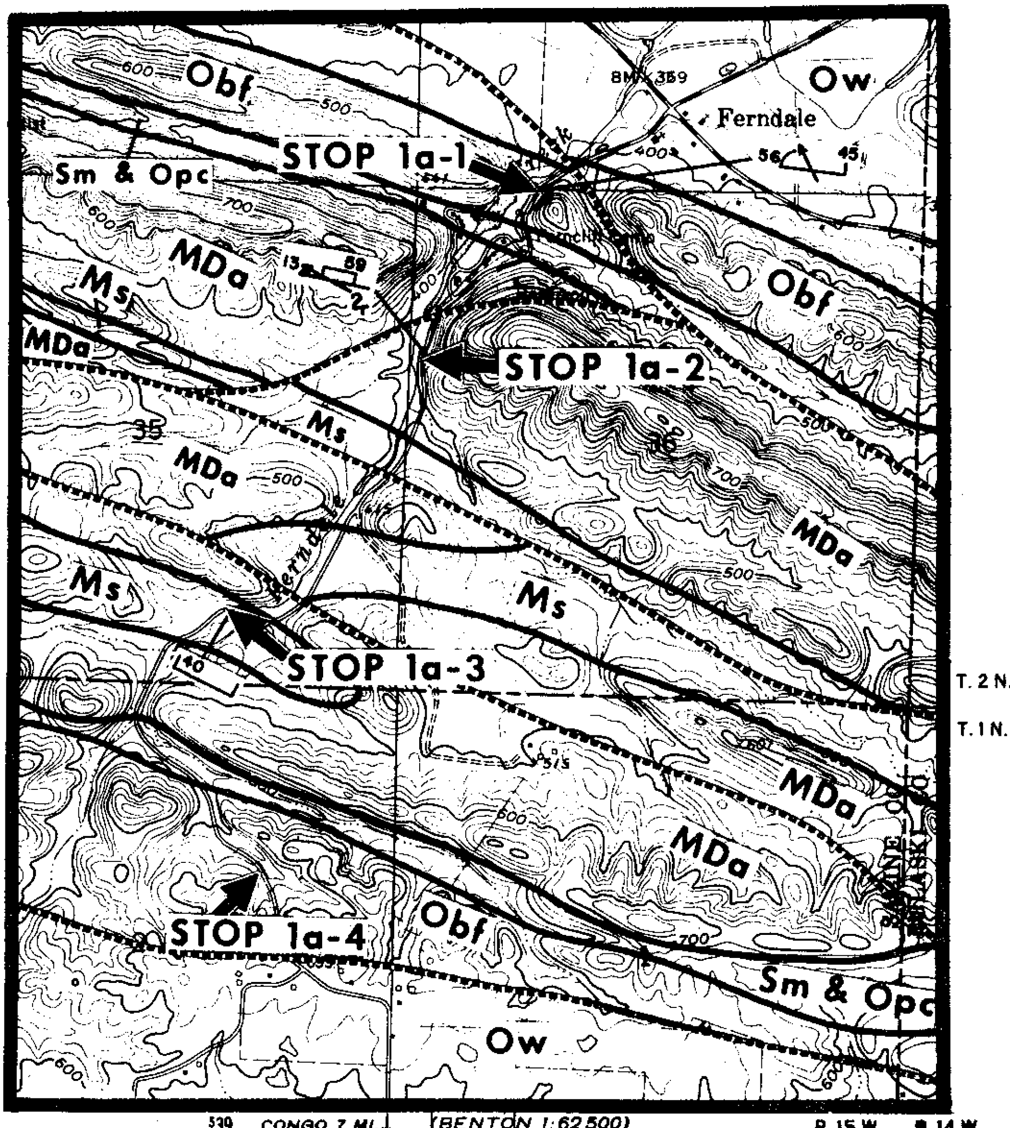


PLATE 14. GEOLOGIC MAP OF FERNDALE, ARKANSAS AND VICINITY-STOPS- 1a, 1, 2, 3, and 4.

1000 0 1000 2000 3000 FEET

Geology by Holbrook, Stone, and Haley

the southwest and have horizontal hinge lines. In outcrops north and west of Ferndale many small folds incline southward but have hinges raking toward the northwest. They are strongly cleaved and probably belong to the Ellis Mountain trend.

1.6 Power line crossing road.

1.7 Valley formed by Middle Division of Arkansas Novaculite.

1.8 Ridge formed by Lower Division of Arkansas Novaculite.

1.9 Valley formed by Missouri Mountain Shale and Polk Creek Shale. A small pit to right (west) has about 8 feet (or about one-half) of the upper Missouri Mountain Shale exposed.

2.1 Poor exposure of Bigfork Chert to east. Note springs in road. In creek to north of culvert are some fresh exposures of black shale and siliceous shale of the Polk Creek Shale with abundant Late Ordovician graptolites.

2.3 STOP 1a-4. UPPER WOMBLE SHALE.

Upright, northward dipping, shales and phosphatic (3 percent P_2O_5) sandstones of the upper Womble Shale. Bottom (load) features occur on some beds. Middle Ordovician graptolites (including Nemagraptus gracilis) of varying size occur in several of the shale beds. This interval is usually present in this region and forms a fairly reliable datum.

2.4 You are crossing recumbent folds, and a folded, low-angle thrust fault in shale and decalcified siltstone of the lower Womble Shale. Note numerous milky quartz veins dissecting the strata.

2.5 Girl Scout Camp to west.

2.7 View to north of large milky quartz vein near trace of folded, low-angle fault. Some of the larger veins were mined locally as a source of exposed aggregate for precase concrete slabs.

3.5 Intensely cleaved (slightly inclined to north) shale of the lower Womble to right.

3.7 A very small exposure of "talcose" shale, with a few flint and meta-arkose pebbles and boulders. This is the Blakely Sandstone which is nicely developed a few miles west on this same trend. This entire belt could well represent a series of complex recumbent folds, with associated low-angle (some folded) thrust faults and the resultant windows and klippen. Locally, the meta-arkose boulder interval is slightly radioactive.

Much of this geology was done by members of the State Survey in the early 1960's with only limited attempts at revisions in the stratigraphic and structural calls since that time, and it is quite obvious that even greater complexities than originally envisioned can be projected this direction from the vicinity of Paron, Arkansas.

3.8 Junction of Ferndale and Colonel Glenn Road. Proceed south.

4.1 Turn to east on dirt road. Dump from abandoned Inman Soapstone Pit to south.

4.15 Milky quartz vein to north in badly faulted and cleaved Womble Shale.

4.5 STOP 1a-5. WARNER SOAPSTONE (FORMERLY DUKE-WARNER) PIT IN WOMBLE SHALE.

This is one of five soapstone pits that are scattered along a narrow, one-mile long, east-west trending belt. The Milwhite Mining Company, Bryant, Arkansas, has been mining these deposits in recent years for various soapstone products (insecticides, etc.). They were first described by Comstock in 1888.

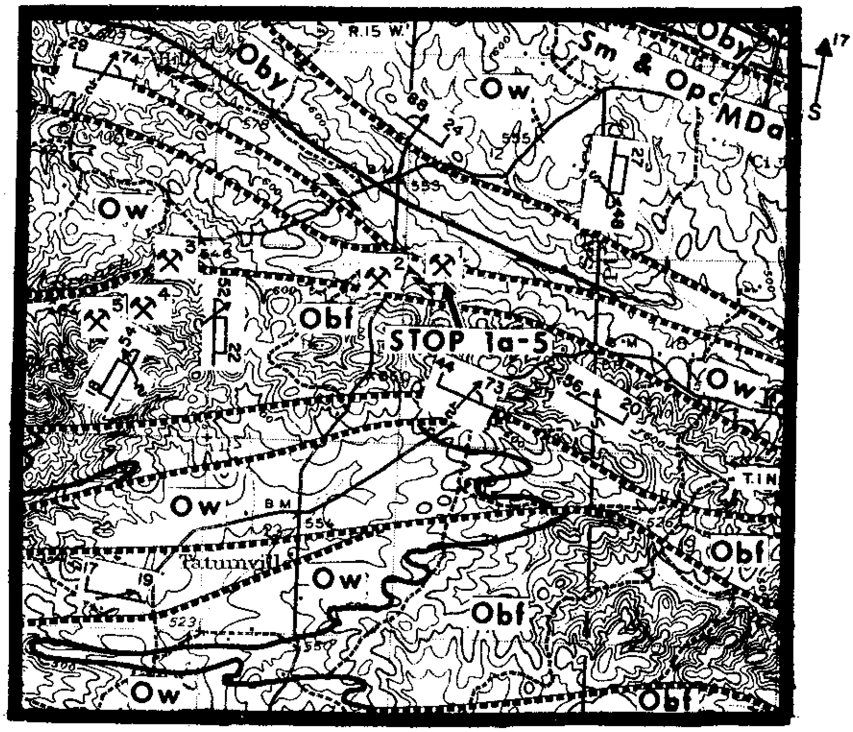


PLATE 15. GEOLOGIC MAP OF SALINE COUNTY SOAPSTONE DEPOSITS-STOP 1a-5.

⚒[1] *Warner pit (See detail map).*
⚒[2] *Inman pit.*
⚒[3] *Moore Branch pit.*
⚒[4] *Anderson pit.*
⚒[5] *Wallis pit.*

1000 0 1000 2000 3000 FEET

Geology by Stone, Haley and Sterling

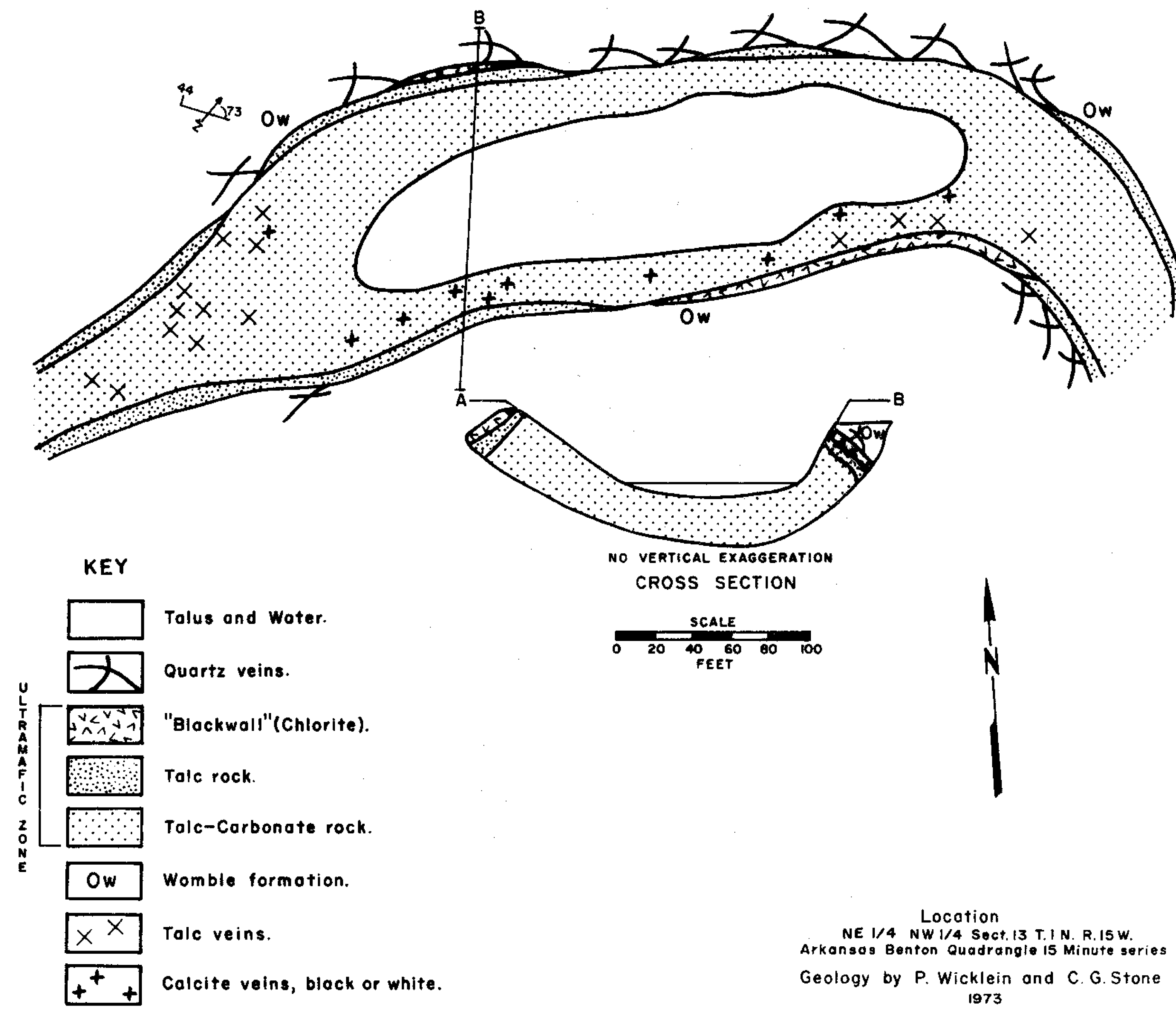
PLATE 16.

GEOLOGICAL MAP OF

WARNER SOAPSTONE DEPOSIT

SALINE COUNTY, ARKANSAS

-STOP 1a-5.



Sterling and Stone (Econ. Geology, 1961) indicate that the sulfide and some silicate minerals in the various soapstone rocks contain significant (probably not economic) nickel. They further note that some serpentine was exposed in one pit and was also encountered in a core hole. Petrographically the serpentine has olivine and pyroxene crystal forms suggesting that the original mass was some type of sill-like peridotite (Kern Jackson, written communication). The sill was intruded into the geosynclinal sedimentary layers of Womble and Bigfork probably in middle Paleozoic time. Subsequently, late Paleozoic steatitization caused by the hydrothermal solutions, which created the bulk of the quartz veins in the Ouachita Mountains, altered most of the parental serpentine rock to soapstone. In 1967, Wicklein (MS thesis at the University of Missouri) further substantiated this theory and developed additional data on the chemistry and mineralogy of the many varieties of sulfide, silicate and carbonate minerals.

Some of the minerals to particularly notice at the Warner Pit are beautiful black and white calcite veins of two different generations cutting soapstone along south wall, shiny veins of crystalline talc at west end of pit, dark green massive chlorite on outer walls of deposit, layered? intervals of sulfides in some varieties of soapstone, and secondary green to white nickel bloom on north wall.

At this stop, attitudes in the Womble Shale are typical of those throughout the northeastern part of the Benton Quadrangle. Folds are greatly inclined to near recumbent toward the south and southwest. Hinge lines rake steeply, mostly toward the northeast, and many are reclined.

BE PARTICULARLY CAREFUL WHEN THIS GROUND IS WET!

Return to Ferndale.

9.0 (28.25) Ferndale Junction, turn west (left) onto Kanis Road.

Contact of soapstone deposits and Womble Shale along north wall of Warner Pit - Stop 1a-5.

View of Milwhite soapstone mining operations at east end of Warner Pit - Stop 1a-5.

ROAD LOG - SECOND DAY

CENTRAL AND SOUTHERN OUACHITA MOUNTAINS, ARKANSAS

Little Rock - Benton - Hot Springs - Crystal Springs - Mt. Ida - Norman - Glenwood - Amity - Bismarck - Arkadelphia - Little Rock

SUMMARY

This trip includes stops in the Early Paleozoic formations of the very intensely folded and faulted central "core area" of the Crystal and Caddo Mountains; the Middle and Late Paleozoic formations of the somewhat less intensely deformed Mazarn Basin and Cossatot Mountains; and Late Paleozoic formations of the more upright but complexly thrust faulted Athens Plateau of the Ouachita Mountains. The trip also traverses gently dipping Mesozoic and Cenozoic formations of the Gulf Coastal Plain near the Fall Line in central Arkansas.

MILEAGE	DESCRIPTION
0.0	Assemble at 7:15 a.m. in front of Sam Peck Hotel. Proceed east on Capitol Avenue.
0.5	Turn north on Cumberland Street.
0.7	Turn east on Interstate 30 ramp.
0.8	Turn south on Interstate 30.
1.1	6th Street Overpass. Continue on Interstate 30 which generally follows the Fall Line separating the Gulf Coastal Plain from the Interior Highlands between Little Rock and Arkadelphia, Arkansas.
1.7	Junction with Roosevelt Road (poor exposures of Midway Group) - continue on Interstate 30.
2.6	Junction of U. S. Hwys. 67 and 167 to Pine Bluff. Stay right on Interstate 30.
3.3	Bridge over Fourche Creek. View of downtown Little Rock skyline to north.

4.9 View of Granite Mountain (a nepheline syenite stock of earliest Late Cretaceous Age) and the 3M Big Rock Quarry operation for road metal, riprap, granules and other materials.

6.0 Exposure of black shale, with iron carbonate concretions in Porter's Creek Formation of the upper Midway Group to south.

6.5 Poor exposures of Wilcox gravel, sand, and clay. The Pulaski County bauxite mines are located about two miles to the south and southeast.

9.7 Arkansas Highway Department Building to north situated on Midway marl and limestone.

10.7 Red sand of the Wilcox Group which locally drapes the Paleozoic rocks.

10.9 Southeast trending ridges formed by intensely folded Bigfork Chert and Arkansas Novaculite.

11.6 Weathered, Womble shale, overlain farther to east by Wilcox sand.

11.9 Affiliated Food Stores to east. At rear of store are exposures of fossiliferous Midway limestone and marl and Wilcox sand. Interestingly, two thin lignite seams were noted at the base of the Midway during excavations for the site.

12.4 Old Limerock Dairy to right (north) with excellent exposures of flat-lying thick, fossiliferous, Midway limestone along small bluff at creek, where some folded Bigfork Chert crops out in stream bed.

13.65 Saline County line.

14.50 View of Alexander Mountain to south. The Wilcox sands, cemented by iron oxides form a resistant cap.

16.0 Weathered exposures of Wilcox sand and clay to north.

17.3 Reynolds Road exit - Bryant and Bauxite. Access road leads to large open pit bauxite mines and Reynolds alumina plant.

18.3 Poor exposures of intensely-folded and sheared Womble Shale, with milky quartz veins and weathered Cretaceous alkalic - lamprophyric dikes.

18.5 Bridge over Hurricane Creek.

19.5 Alcoa Road exit - leads southward to large Alcoa alumina plant.

21.9 Edward's Rock Shop and Indian Museum to north.

22.7 Gravel and sand pits in Wilcox Group to north.

23.3 Junction of Ark. Hwy. 5 (continue east on Interstate 30).

23.6 Flat-lying fossiliferous Midway limestone in McNeil Creek to (left) east; recumbent folds in Womble silty limestone and shale to west of small bridge.

24.5 Benton, Arkansas (downtown to southeast).

25.1 Gravel pits to south.

25.3 Bridge over Saline River.

26.0 Good exposure of fossiliferous limestone (often containing a chert pebble conglomerate) - and marl of the Midway Group, overlying with angular unconformity the highly cleaved and recumbently folded Womble shale and calcareous siltstone.

26.7 Shark and crocodile teeth occur in lower Midway marl and limestone in small field to (left) south.

27.9 Exposure to north of intensely folded (recumbent) Womble Shale overlain with major angular unconformity by the nearly flat-lying Cretaceous-

Paleocene deposits of Arkansas Novaculite boulders. Notice the white Arkansas Novaculite boulders in the pebbles and silt. The nearest Arkansas Novaculite crops out about eight miles to the southwest. Stone and Sterling (December 1965, GSA, v. 76, p. 1393-1400) have interpreted these deposits as being derived by mud and debris flows from topographically high Arkansas Novaculite outcrops to the southwest during very late Cretaceous or possibly very early Paleocene time.

28.3 Interstate 30 and U. S. Hwy. 70 (Hot Springs) interchange, turn right (west) onto U. S. Hwy. 70.

28.9 Small recumbent folds and intense axial plane cleavage developed in Womble shale and calcareous siltstone. Note the weathered lamprophyric igneous dike.

29.3 Small folds in Womble siltstone and shale on the upper limb of a major recumbent structure.

A few hundred feet to the south is the old abandoned fuller's earth mining district. In the early 1900's high-grade fuller's earth for refining edible oils was mined from weathered lamprophyric dikes.

29.4 Along much of the route of the small stream to north adjacent to dirt road, nearly horizontal beds of silty, dense, gray limestone and shale in the lower Womble Shale are nicely exposed. The apparent tops of the beds exhibit abundant flute casts and related bottom markings. A nearly horizontal cleavage is present in some of the thin shales. Recumbent folds, nappes, decollements and other complex structural features are clearly exhibited in the easterly "core area" of the Ouachita Mountains.

29.6 Axial plane cleavage is nicely developed in Womble Shale to north.

29.8 - 30.0 Complexly folded Womble Shale with a small weathered lamprophyric igneous dike (Late Cretaceous) and dissecting quartz veins (Pennsylvanian-Permian).

30.6 Fresh exposures of banded Womble Shale with many small recumbent folds and nearly horizontal axial plane cleavage occur in the drainage ditch to north.

30.8 Weathered exposures of upper Womble silty sandstone and shale.

31.2 Poorly exposed upper Womble silty sandstone and shale to north.

31.3 Junction with dirt road to south (left). Some graded, bottom-marked graywacke occurs along the small creek some 350 years to the south in the upper Womble Shale. Nearly horizontal cleavage extends across these rather steeply inclined beds.

32.2 Bridge over small creek.

32.3 Highly cleaved Womble shale, with a weathered (red clay) lamprophyric dike cutting the sequence.

32.8 Intensely folded upper Womble Shale with numerous weathered dikes mostly of lamprophyric composition.

33.2 Ten Mile Creek Bridge.

33.7 Reddish weathered sandstones in upper Womble Shale to north.

34.2 Note flat topographic surface. Apparently an erosional feature developed by the Saline River during a Pleistocene epoch.

34.6 Large weathered lamprophyric dike to north cutting the upper Womble Shale.

34.9 Rural Dale School Area. Outcrops in upper Womble Shale (Ordovician) near the western boundary of the Saline Basin. In this region there are numerous weathered, lamprophyric-phonolitic dike swarms (Late Cretaceous) that are genetically related to the Magnet Cove and Wilson Springs intrusives a few miles to the south.

35.3 Junction of Ark. Hwy. 88 with Lonsdale, Arkansas to south. Continue west on U. S. Hwy. 70. Note numerous reddish-weathered lamprophyric dikes.

35.6 Swarms of weathered lamprophyric dikes cutting upper Womble Shale and milky quartz veins.

36.7 Owensville road junction. Small white (weathered) phonolitic dikes cut the upper Womble sandstones and shales to the south.

37.2 Upper Womble Shale with numerous, small, weathered igneous dikes.

38.0 Hill capped by siliceous shale (lowermost Bigfork Chert) cut by several small, weathered igneous dikes.

38.2 Uppermost Womble Shale with some milky quartz veins.

39.0 Contact of the Womble Shale and the overlying Bigfork Chert. You are now leaving the Saline Basin and entering the Zigzag Mountains.

39.3 Good exposure of highly fractured Bigfork Chert. Notice soft, sooty, carbonaceous zones which are often developed in the lower Bigfork Chert in the region. Well-developed recumbent chevron folds and nearly flat-lying axial plane cleavage typify the exposure. A spectacular weathered phonolitic dike cuts the sequence.

39.5 Ten Mile Creek bridge.

40.0 STOP 2-1 (20 MINUTES) FOLDED BIGFORK CHERT AND WEATHERED DIKE.

Large overturned chevron fold in the fractured chert, siliceous shale, and calcareous siltstone of the Bigfork Chert. Minor amounts of shale and punky, carbonaceous material are present. Fracture cleavage occurs in the axial regions of the folds. A spectacularly exposed, weathered lamprophyric dike cuts the sequence.

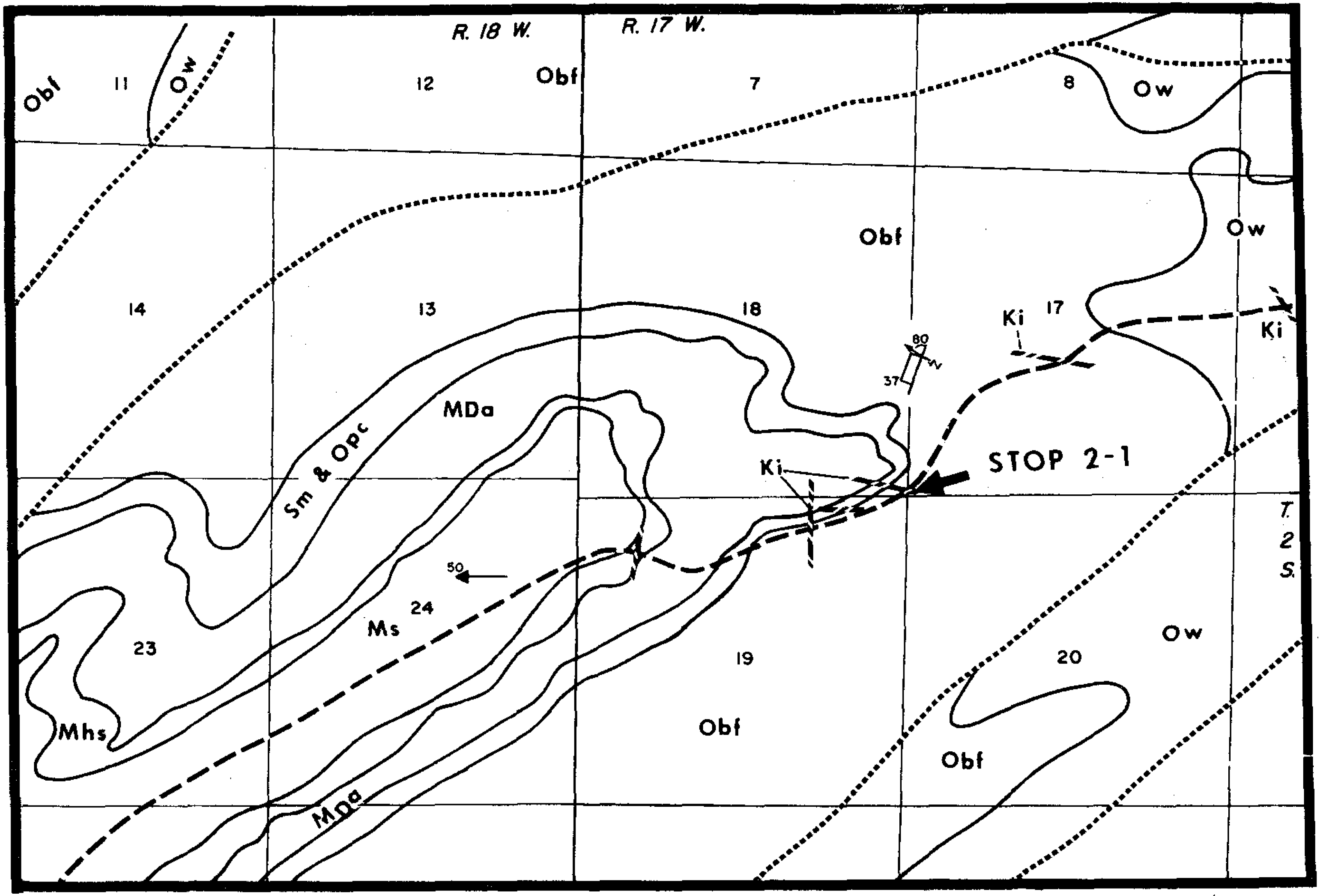


PLATE 17. GEOLOGIC MAP OF EASTERN GARLAND COUNTY ALONG U.S. HIGHWAY 70- STOP 2-1.

0 1 2 Miles

N

Geology by Purdue and Miser, modified by Stone and Haley.

The Bigfork Chert is the most reliable aquifer in the Ouachita Mountains and often has small, chalybeate springs issuing along the base of the exposures. Note the small pine trees growing on an essentially vertical face in the Bigfork Chert.

From Benton to Hot Springs, Arkansas our route crosses first the southern part of the Saline Basin "core area" in the Benton and Lonsdale Quadrangles and then the Zigzag Mountains and the eastern end of the Mazarn Synclinorium in the Hot Springs Quadrangle.

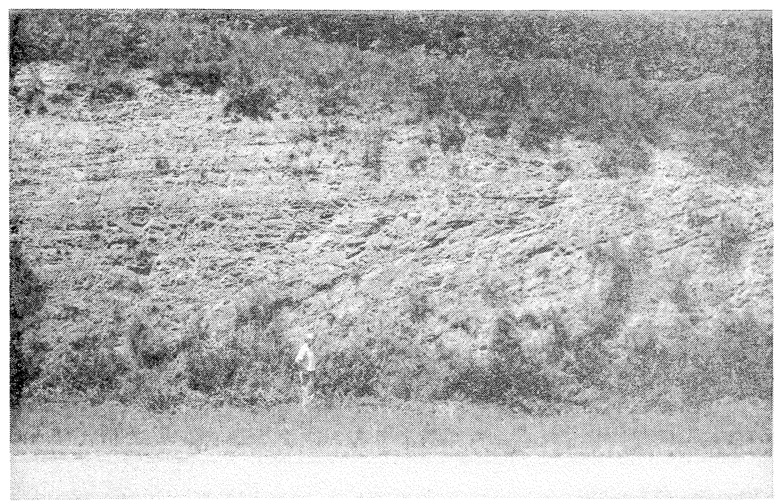
In the southern part of the Benton Quadrangle, folds, largely in the Womble Shale, are recumbent. The axial planes form a broad low arch, for they dip toward the north or northwest in the western part of the quadrangle but toward the south in the south central portion. The arch thus formed has a northeast-southwest (Hot Springs?) trend. Hinge lines in the southwest generally are horizontal; those in the south central part are raking or reclined. The direction of overturning is dominantly toward the southeast. Farther toward the northeast we cross the main northwest-southeast axis of the Benton-Broken Bow uplift, and the near recumbent axial planes take on a northeastward dip. Fold hinges are dominantly reclined, raking 80° or more toward the northeast. Also in this area we find isolated exposures with folds down-facing toward the north.

40.2 Another good exposure of the Bigfork Chert with small weathered igneous dikes, near the axis of a large overturned anticline in the Zigzag Mountains.

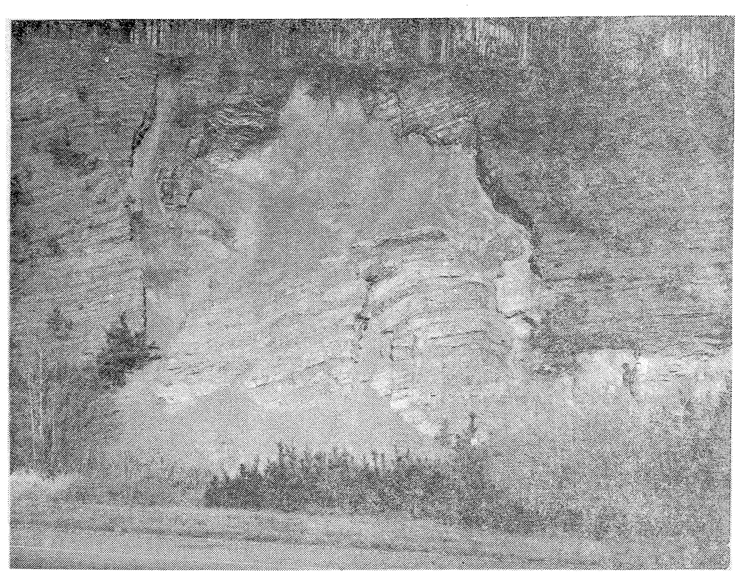
40.5 The thin Polk Creek Shale (Late Ordovician) and Blaylock Sandstone (Silurian) appear to be removed by minor faulting at this locality, and the Bigfork Chert is in contact with the Missouri Mountain Shale.

Arkansas Novaculite boulders in Cretaceous-Paleocene deposit, resting with angular unconformity on the Womble Shale on the right (north) side of Interstate Highway 30 at mileage 27.9.

A large fold in the Bigfork Chert at the north end of Stop 2-1.



Lamprophyric dike intruding along joint systems in the Bigfork Chert - Stop 2-1.



40.6	A good exposure of upright, northwestward-dipping, pinkish-buff shaly slate with some very thin, medium-grained sandstone of the Missouri Mountain Slate, overlain by the very massive, dense, jointed, white, Lower Arkansas Novaculite (Devonian). A weathered phonolitic dike (buff) cuts the novaculite.
40.9	Gray chert and siliceous shale in the folded Middle Division of the Arkansas Novaculite.
41.0	White tripolitic novaculite in the Upper Division of the Arkansas Novaculite.
41.1	Quartzitic, often conglomeratic, sandstone and shale in the Hot Springs Sandstone Member of the Stanley Shale.
42.1	Large overturned fold in brownish-weathered lower Stanley near the center of a southwestward-plunging (12°-15° per mile) syncline.
42.4	Rest Area to south. Commercial whetstone quarries in Lower Division of Arkansas Novaculite on ridge to north.
42.7	Interbedded graywacke sandstone and shale of the lower Stanley Shale. Thin resistant beds at top of cut are very tuffaceous and are considered equivalent to the Hatton Tuff.
43.2 - 43.4	Good exposures of highly sheared shale with minor amount of graywacke in the lower Stanley Shale.
45.3	Minutely folded and cleaved lower Stanley shale and silty sandstone.
45.9	Massive, southward dipping, sandstone in the lower Stanley to the north.
46.2	Thin, southward dipping, graded, sandstone and shale in the lower Stanley, with some milky quartz veins.

46.6 McClendon Mineral Springs to right.

47.0 Bridge over small creek. Note broken dam on small man-made lake to north. Flash-floods are particularly ferocious beasts!

47.1 - 47.3 An excellent exposure of fresh Stanley slate, shale, and graywacke with numerous small overturned folds and associated cleavage.

48.0 Lower Stanley Shale in roadcuts.

48.2 Junction with Westinghouse Road to south, continue on U. S. Hwy. 70. Fold hinges in this part of the Mazarn synclinorium plunge generally toward the southwest, though a few reclined hinges plunge toward the northwest. Axial surfaces consistently dip to the northwest.

48.6 Junction with Pennsylvania Avenue.

49.4 Exposure of lower Stanley Shale with a view to north of the Zigzag Mountains and the Hot Springs area.

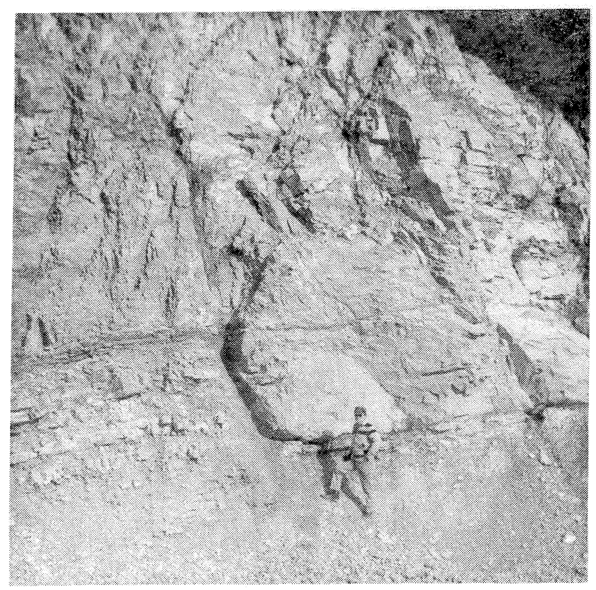
49.7 Bridge over creek.

50.3 - 50.6 There are several excellent exposures with intensely folded and faulted lower Stanley Shale containing milky quartz veins and igneous dikes in this area (particularly on southwest side of road).

Bottom marks and graded bedding are noticeable in some sandstones and indicate major overturning and gravity sliding (?) southward into the Mazarn Basin. Fracture cleavage and flexural-flow folding are well-exhibited in all the roadcuts. On Indian Mountain, towards the north, the Hot Springs Sandstone is quarried for road metal and the Upper Arkansas Novaculite for tripoli.

51.1 Gulpha Gorge exit, continue on U. S. Hwy. 70.

Massive Arkansas Novaculite overlying the thin chert and shale of the Missouri Mountain, with a small fault zone on the north side of U. S. Highway 70 at milage 40.6.



Very complex minor structures in alternating thin sandstone and shale of the lower Stanley on the west side of U. S. Highway 70 near Howard Johnson's at milage 50.3.

Southward verging fold in shale and sandstone of the upper Blakely at the west end of Stop 2-2.

51.5 Excellent exposures of Hot Springs Member of the lower Stanley, the Arkansas Novaculite, the Missouri Mountain and the Polk Creek Formations along the road through Gulpha Gorge.

51.9 Coy's Restaurant to west. A superb dining establishment!

52.9 Junction with U. S. Hwy. 270 (Malvern Street) leads north to Hot Springs Business District. Continue westward on U. S. Hwy. 70.

53.4 Junction of U. S. Hwys. 70 - 70B - 270 and Ark. 7. Continue westward on 70 and 270.

55.4 Junction of U. S. Hwys. 70 and 270. Turn right (to west) follow Hwy. 270. In the roadcuts are sheared shale or slate and lenticular graywacke of the lower Stanley Shale along several faulted structures on the north flank of the Mazarn topographic and structural basin.

56.3 Overturned, northward dipping, often crinkled and sheared lower Stanley Shale on both sides of road.

57.3 - 57.6 Exposures of the Stanley Shale on both sides of road. To the northeast is West Mountain formed by the Hot Springs Sandstone and the Arkansas Novaculite.

57.9 Bridge over a prong of Lake Hamilton.

58.2 Junction of U. S. Hwy. 270 and Ark. Hwy. 227, continue on Hwy. 270.

58.9 Exposures of Stanley Shale and sandstone to south.

60.7 A good exposure of sheared shale and rather lumpy graywacke of the lower Stanley Shale to south.

61.5 Bridge over upper end of Lake Hamilton (Ouachita River).

64.9 Royal, Arkansas.

65.5 Road to north leads to Brady Mountain Resort on Lake Ouachita (Bear, Arkansas, is about 1 mile). In the late 1800's the Bear Community was the center of intensive lead-zinc-silver-gold prospecting. Little ore was produced, however, and eventually the prospectors left for better pickings.

65.8 Bridge over creek.

66.9 Junction of U. S. Hwy. 270 and Ark. Hwy. 227, continue on Hwy. 270.

68.2 Bridge over creek.

68.3 A poorly-exposed, faulted sequence of Arkansas Novaculite, Missouri Mountain Shale and Polk Creek Shale along the southern border of the central "core area" of the Ouachita Mountains.

68.6 On the south (left) side of road is the home of former Arkansas Governor, Colonel Elias W. Rector, the father of the Arkansas Geological Survey under Dr. John C. Branner, State Geologist 1887-1893. Dr. Branner and his staff were truly among the most diligent and resourceful geologists in America at that time.

69.4 Several small exposures of the rubbly Bigfork Chert for the next 0.9 miles.

70.3 Contact between Bigfork Chert and Womble Shale to west.

70.4 An abundant Middle Ordovician graptolite fauna, commonly known as Normanskill Shale fauna (see illustration) occurs in black carbonaceous shales of the upper Womble Shale on north side of road.

70.5 Crystal Springs, Arkansas. Road to south leads to abandoned road metal quarry in the thin-bedded, southward overturned, Bigfork Chert. Miser (oral communication) reported that lingula in association

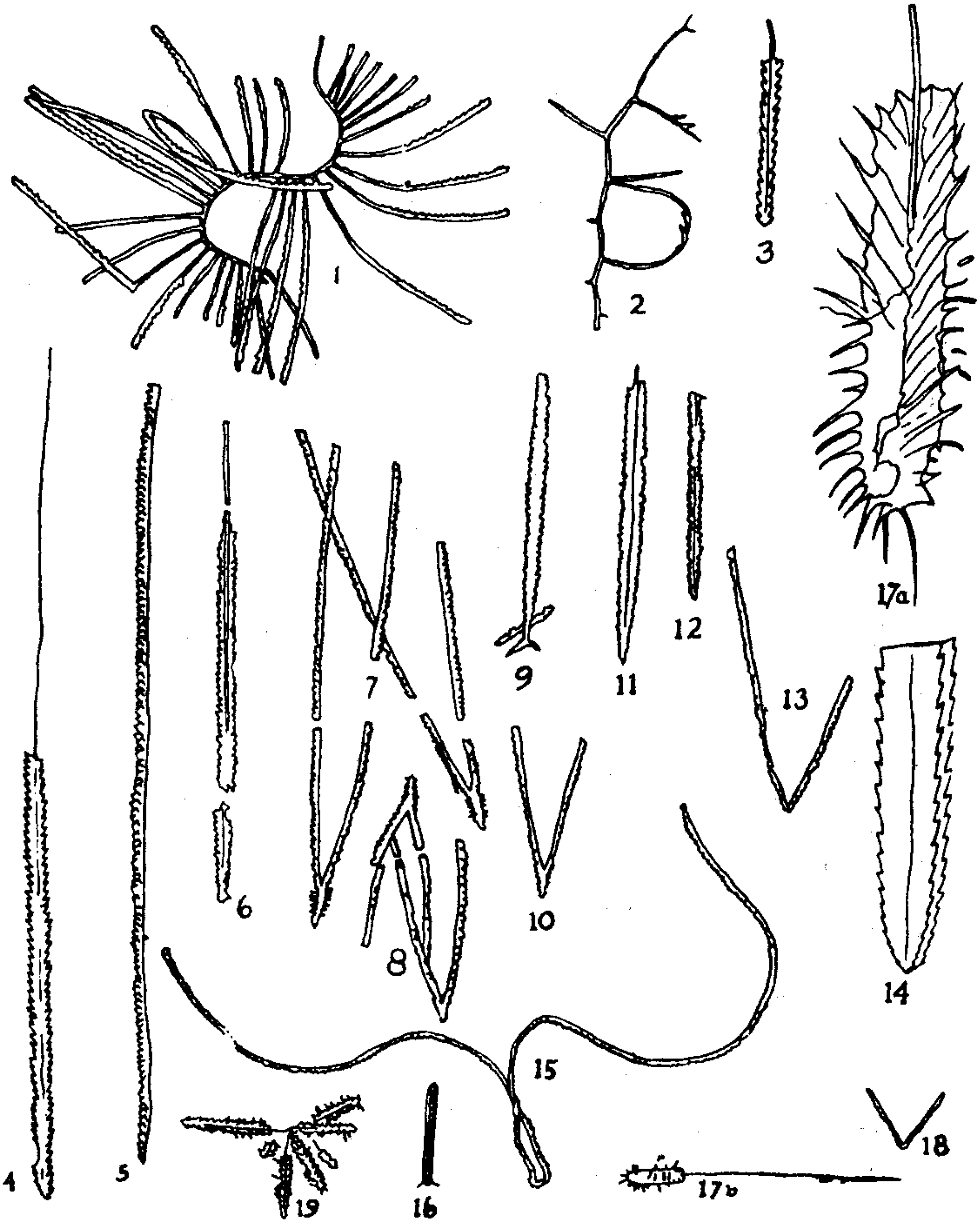


Figure 1. Graptolites

1 - Nemagraptus gracilis Hall
2 - Thamnograptus capillaris (Emmons)
3 - Glyptograptus angustifolius (Hall)
4 - Diplograptus foliaceus incisus (Lapworth)
5 - Didymograptus sagitticalis (Gurley)
6 - Diplograptus basilicus (Elles & Wood)
7 - Dicranograptus nicholsoni parvangulus Gurley
8 - Dicranograptus diapason Gurley
9 - Climacograptus bicornis Hall
10 - Dicranograptus rectus Hopkinson
11 - Diplograptus acutus (Elles & Wood)
12 - Glyptograptus euglyphus Lapworth
13 - Dicellograptus divaricatus rigidus Elles & Wood
14 - Retiograptus geinitzianus Hall
15 - Dicellograptus gurleyi Lapworth
16 - Cryptograptus tricornis (Carruthers)
17 - Glossgraptus ciliatus Emmons
18 - Dicellograptus sextans (Hall)
19 - Lasiograptus mucronatus (Hall)

GRAPTOLITES FROM WOMBLE SHALE AT CRYSTAL SPRINGS, ARKANSAS.

From Guide Book of 5th Annual Field Conference - Kansas Geological Society 1931 with graptolites were found in dense limestone in the Womble Shale along small creek immediately north of town. Blakely sandstone and shale crop out along roadcut a short distance farther to the north.

71.1 The Texas tunnel, one of the many misdirected early mining ventures in the Ouachita Mountains for precious metals, was dug in carbonaceous graptolitic shale of the extreme upper Womble.

72.9 Exposure of middle Womble Shale to south.

73.2 Intricately-folded and highly-cleaved shale and limy siltstone of lower Womble Shale.

73.2 STOP 2-2. (25 MINUTES) BLAKELY SANDSTONE AT CHARLTON RECREATION AREA.

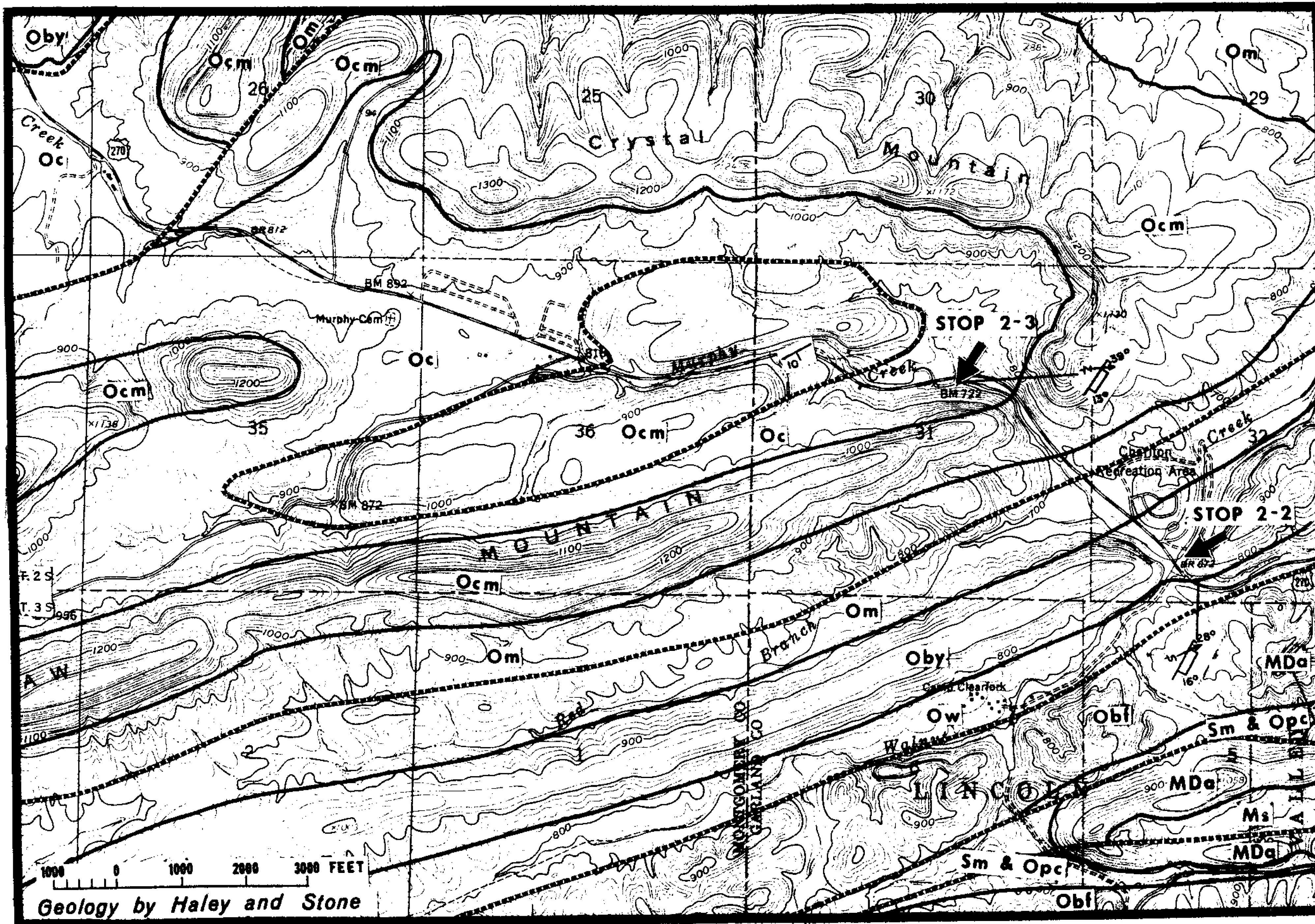
Intensely folded (overturned to south with fold axes plunging to east and somewhat faulted), massive to thin quartzitic sandstone, laminated shale and calcareous (?) siltstone of the Blakely Sandstone are exposed along the roadcuts and the trail leading northward along Murphy Creek to an old "gold-silver" tunnel. Notice discontinuous sandstone masses, pull-aparts, and some excellent axial-plane cleavage. Near east end of exposure there are two somewhat weathered monchiquite dikes. An excellent exposure of upper Mazarn banded shale, and thin sandstone, and siltstone occurs along small stream to the west of highway bridge.

Continue westward on U. S. Hwy. 270.

73.9 Exposures of rubbly massive sandstone of the ridge-forming Crystal Mountain Sandstone. An old manganese mine occurs to the south in the lower part of the formation.

74.2 STOP 2-3. (25 MINUTES) RECUMBENT FOLDS IN COLLIER LIMESTONE.

Flaggy to fairly massive, dense, gray, complexly folded Collier limestone and shale. Nearly flat-



R. 23 W. R. 22 W

PLATE 18. GEOLOGIC MAP OF McGRAW MOUNTAIN AREA-STOP 2-2.and 3.

lying axial-plane cleavage with particular flowage of thin "talcose" shale into axes of folds. Small pellets or oolites occur in massive limestone to south of bridge and seem to be a good marker horizon for the Collier Shale throughout this region. Notice small fracture-filling quartz-calcite vein systems. Recently, Ethington and Repetski at the Universtiy of Missouri have identified Lower Ordovician conodonts from Collier Limestone samples. collected in the area.

At first inspection the large fold in the McGraw Mountain-Crystal Mountain area appears to be relatively simple. It is southeastward inclined and hinge lines plunge toward the east. Small, parasitic folds exhibit an S rotation on the southern overturned limb (Stop 2-2) and a Z rotation on the long upright limb at Stop 2-3. The area of Crystal Mountain Sandstone in the center of the fold seems to be a small synclinal dimple on the long limb of the fold. The trouble is that the Crystal Mountain dips under the Collier in all directions. Therefore, the contact must be a thrust fault, which has been backfolded toward the south with the other strata. The outcrops of Crystal Mountain Sandstone just west of Stop 2-3 lie in windows of the thrust.

Continue west on U. S. Hwy. 270.

74.4 Monte Cristo rock shop to south.

74.5 Small excavation to west represents a recent attempt to mine quartz crystals from veins in the Crystal Mountain Sandstone.

74.6 A good exposure of apparently upright (anticlinal) Crystal Mountain sandstone (calcareous?) and interbedded shale. Notice small quartz veins cutting the strata. See map for geological interpretation of area.

74.8 Montgomery County line.

Recumbent folds in dense, flaggy, gray limestone of the Collier at Stop 2-3.

Close-up of previous picture showing intricacies of the folding with horizontal axial plane cleavage. Notice that some black "talcose" shale separates many of the limestone layers.

View of Collier exposure slightly downstream (south) with some massive, locally pelletoidal limestone.

75.1 Massive, steeply dipping, somewhat broken, sandstone of the Crystal Mountain Sandstone to north (right).

75.3 Poorly exposed Collier Shale.

75.5 High hills in all directions are formed by the Crystal Mountain Sandstone.

76.4 Very intensely folded, dense, flaggy to thin-bedded Collier limestone to north. Abundant small quartz-calcite veins.

76.7 Steeply dipping, massive sandstone of the Crystal Mountain Sandstone to north.

76.9 Very intensely folded, dense, flaggy to thin-bedded Collier limestone to east. Notice white quartz-calcite veins.

77.0 Approximate trace of major low-dipping thrust fault.

77.1 Exposure of broken, massive to thin-bedded sandstone and shale of the Blakely Sandstone.

77.6 Gap Creek Recreation Area to south. Exposures mostly lower Womble shale, calcareous siltstone and some very thin sandstone from here to Mt. Ida, Arkansas.

77.8 Excellent exposure of complexly folded lower Womble calcareous siltstones and shales. Note northeast trend of folds and also small quartz veins.

77.9 Joplin, Arkansas.

78.8 STOP 2-4. (15 MINUTES) INTENSELY FOLDED LOWER WOMBLE SHALE.

This excellent exposure of interbedded shale, decalcified siltstone and some thin sandstone of the lower portions of the Womble Shale contains two or more distinct and well illustrated fold directions. Notice well-developed

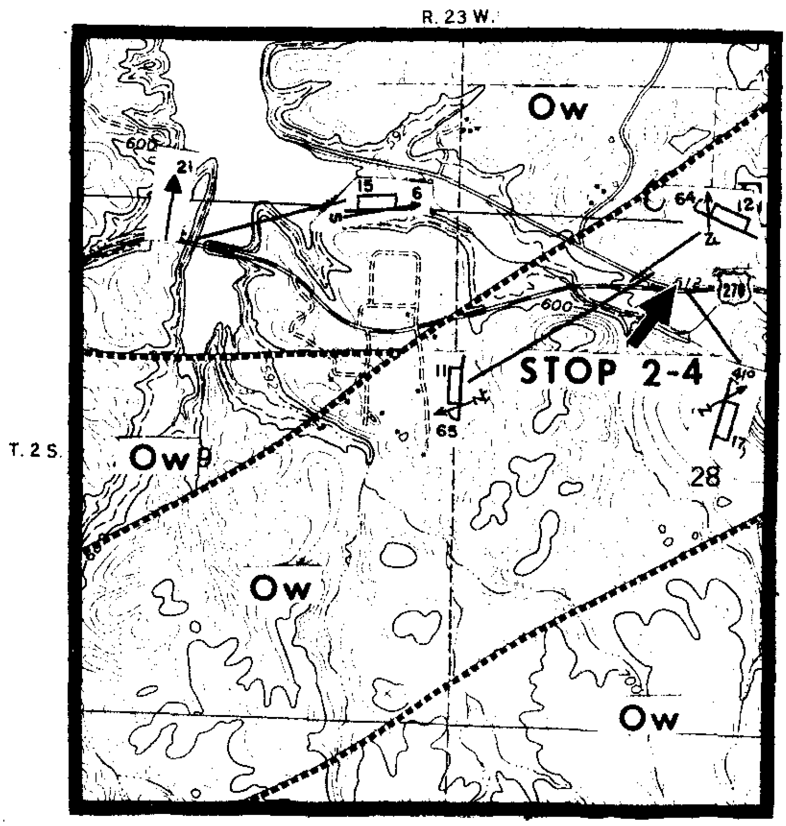
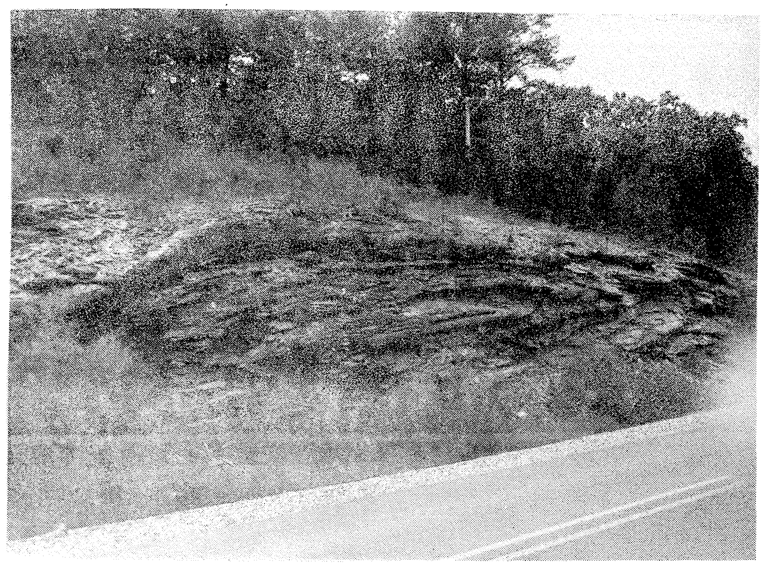


PLATE 19. GEOLOGIC MAP OF DENBY CREEK AREA-STOP 2-4.

1000 0 1000 2000 3000 FEET

Geology by Haley and Stone



Extremely tight fold cylinders or axes in limy siltstone and shale of the Womble, trending east-northeasterly on the west side of Denby Creek at mileage 79.8.

axial-plane cleavage and flowage of units. Small quartz veins containing calcite and adularia (?) were noted at this locality.

Folds at this stop are either gently inclined or recumbent. The dips of axial surfaces box the compass, though gentle dips toward the east and northeast predominate. Fold hinges swing from northeastward plunges through an angle of 60 degrees to north-northwest plunges, yet all appear to lie within the broadly-warped axial surfaces. Part of this variation in trend could be ascribed to folding by passive flow parallel to the axial surfaces; part is undoubtedly due to a later broad arching around a north-plunging axis, and part is due to a southward-directed folding cutting obliquely across an earlier set of hinge lines. Rotation directions visible in the outcrop are related to southward-directed folding. The same change in trend occurs a short distance west of here at Denby Creek Bridge.

79.0 Bridge over creek.

79.1 Exposure of highly cleaved and recumbently folded Womble Shale to the south.

79.8 Denby Creek bridge and Lake Ouachita. <u>Drive slowly</u>!

79.9 To south are many fold axes or cylinders parallel to roadcut, with a slight plunge usually to east, looking right at you. (This exposure is too dangerous for a stop, but contains several periods of folds.) One system could be related to an earlier sedimentary flow or slide phenomenon.

80.8 Silver, Arkansas. Small fracture-filling quartz veins containing calcite (some pinkish tinted) with varying proportions of adularia, pyrite, and silver-bearing galena, sphalerite, chalcopyrite, tetrahedrite and other minerals were mined prior to 1900 at several prospects in this vicinity.

83.2 View of the Crystal Mountains subprovince to south.

84.4 Bridge over creek.

84.5 Junction with Logan Gap Road to south. (see supplementary second day road log - Crystal Mountains at Collier Springs - p. 106)

85.1 Low hill to southwest is formed by the Blakely Sandstone.

85.65 Bridge over Shady Creek.

86.2 Good view of Fisher Mountain and other Crystal Mountains to south. Womble Shale exposed along the highway.

86.5 Hurricane Grove, Arkansas.

87.9 A very large Z fold in Womble silty limestone and shale occurs on bank of Williams Creek to west.

88.0 Bridge over Williams Creek.

89.0 City limits of Mt. Ida, Arkansas.

Dirt road to south leads to Ocus Stanley mineral shop - one of the larger dealers in the clear quartz crystals. Quartz crystals have been mined in Arkansas for many decades, first by the Indians who shaped them into arrowheads and more recently by white men who have used them for making optical equipment and jewelry. Stones that are cut from quartz crystals are sold in Hot Springs under trade name of "Hot Springs diamonds". These should not be confused with genuine diamonds from diamond mines of Murfreesboro, Pike County, Arkansas, nor with "rock crystal" (glass). Most of the quartz crystals from Arkansas find their way into mineral collections of institutions and individuals, and a relatively large volume is used in construction of water fountains and religious and memorial shrines. The value of the natural crystals sold each year has ranged from a few hundred to many thousand dollars.

In recent years, especially during World War II, there was a great demand for oscillator quartz. At that time quartz crystal mining was greatly accelerated by individuals, the Diamond Drill Carbon Company, and the U. S. Government. Clear crystals of oscillator grade are, however, so scarce that only about 5 tons were produced during the war years. This quantity was very small in comparison with the war-time requirements of 2,000 tons nearly all of which was imported from Brazil.

The quartz crystal deposits are numerous and are found at many localities in a wide belt extending from Little Rock westward almost to Mena. They and their few associated minerals are hydrothermal deposits formed mostly during the closing stages of the Late Pennsylvanian - Early Permian orogeny in western Arkansas and eastern Oklahoma.

90.0 Junction of U. S. Hwy. 270 and Ark. Hwy. 27, turn west on Hwy. 27.

90.6 Highly cleaved and folded, fresh, black shale and calcareous siltstone of the Womble in small creek to west.

91.7 - 91.9 Sequence of sheared black shale of the Womble Shale, proceeding to a large low-angle fault zone, then to massive, calcareous broken sandstone of the Crystal Mountain Sandstone finally into the poorly exposed shale and dense limestone of the Collier Shale.

92.0 Good exposure of gray, flaggy to thin-bedded, dense, Collier limestone in bank to west. Notice abundant milky quartz-calcite veinlets.

92.45 Intensely folded Collier limestone, "talcose" shale and flint stringers, with small quartz-calcite veinlets, crops out in small gulley to west.

93.4 Collier shale and thin limestone crop out in ditch to east.

93.7 Weathered shale and punky decalcified siltstone with quartz veins of Collier Shale to east. To the west of this area in a roadcut in the NW¼SE¼ sec. 35, T. 2S, R. 26W., Orville Wise of the Arkansas Geological Commission and others have found some small, possible algal structures in thin, flaggy, Collier limestone. A flint-pebble conglomeratic limestone with some small plagioclase (?) fragments also occurs in a small stream just north of that locality.

94.1 View of ridge to south formed by Crystal Mountain Sandstone.

94.55 A good exposure of intricately folded Collier limestone occurs a few hundred feet upstream (west) from bridge.

95.0 Some fairly massive beds of conglomeratic, pelletoidal, oolitic Collier limestone occurs in ditch to east.

95.5 - 95.7 STOP 2-5 (20 MINUTES) CRYSTAL MOUNTAIN SANDSTONE

When this road was re-surfaced a few years ago, excellent recumbent folds, cleavage, and sedimentary features were well-exhibited by the alternating massive to thin, sometimes calcareous, often quartzitic sandstone and clayey to carbonaceous shale of the Crystal Mountain Sandstone. A large fold could be easily seen along the northern extremities of this exposure (west side of road) and excellent top and bottom criteria indicated the northward shallow-dipping

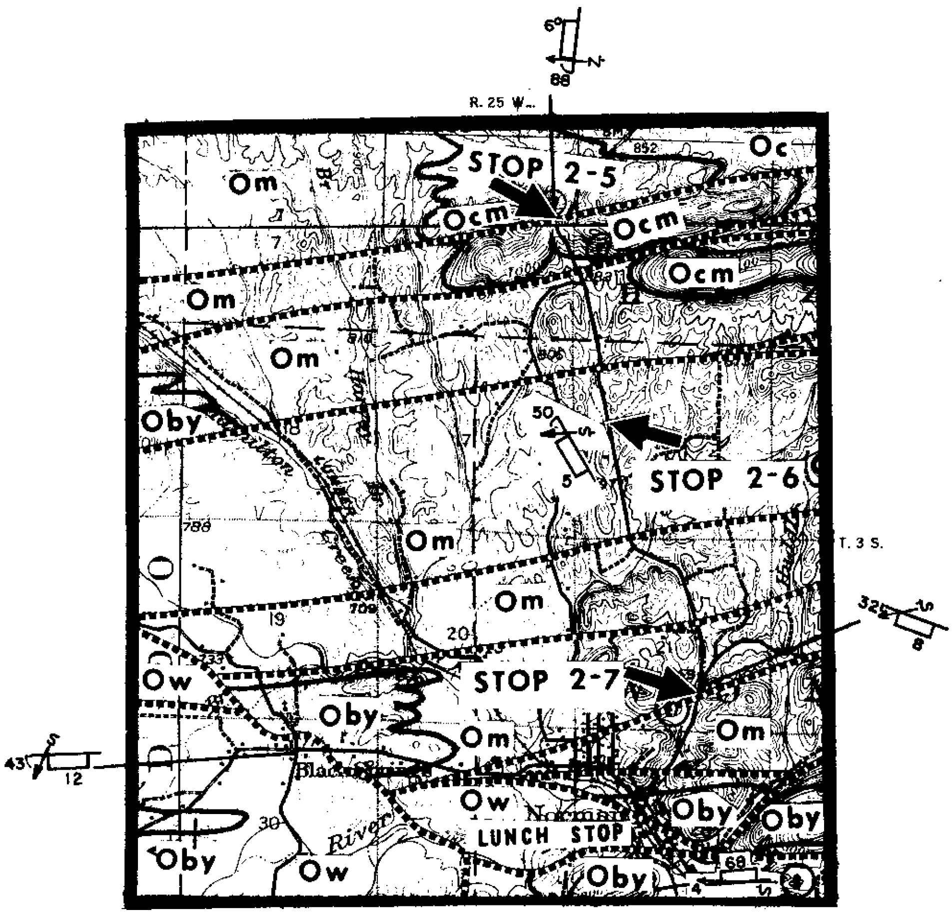


PLATE 20. GEOLOGIC MAP OF NORMAN, ARKANSAS AND VICINITY-STOPS 2-5, 6, and 7.

1000 0 1000 2000 3000 FEET

Geology by Purdue and Miser, modified by Stone and Haley.

sandstone beds were upside-down and confirmed that older rocks of the Collier Shale were to the north. Note thin fracture-filling quartz veins and crystals.

Between Mount Ida and Norman, Arkansas, fold attitudes are fairly constant. Axial surfaces are moderately inclined or recumbent, and they exhibit gentle warping. The fold hinges consistently plunge toward the west or southwest parallel to the trends and plunges shown by the map pattern. Rotation directions are consistently toward the south.

The only problems occur in places such as Stop 2-6 where if our top and bottom calls are correct, the rotation directions suggest an overturned, northward-moving limb. This is not completely anomalous, for we suggest initial movement toward the north, and at later stops we shall see definite proof for it.

Tentatively the name <u>Crystal Mountain trend</u> is applied to these folds. The bearings of fold hinges in the Crystal Mountains are the same but the axial surfaces appear to be much steeper. Only more work will reveal whether this represents the effect of thick sandstones in the stratigraphic section or if the steep axial surfaces are related to a later phase of folding.

95.8 Exposure of banded shale and thin siltstone of Mazarn Shale to east at electrical power relay station.

96.4 Spring fed ponds to west probably derived from isolated intervals of dense Mazarn limestone.

96.7 <u>STOP 2-6. (15 MINUTES) COMPLEX STRUCTURE IN MAZARN SHALE AND LIMESTONE</u>.

This is an excellent exposure of banded slate and dense, often silty, gray limestone of the severely folded Mazarn Shale. Notice flowage of units, and minor faults. Also quartz vein with calcite and high degree of weathering. The complexity in this exposure is attributed to both structural deformation and soft sediment slide accumulations.

98.1 Junction of dirt road to east and supplementary second day road log Crystal Mountains at Collier Springs.

98.1 STOP 2-7. (20 MINUTES) FOLDED UPPER MAZARN SHALE, SILTSTONE AND SANDSTONE.

This is a highly folded and cleaved sequence of alternating banded shale, thin siltstone and quartzitic, lenticular, sandstone of the upper Mazarn Shale. Excellent top and bottom criteria indicate direction of overturning is to south. Likely the banding in the shale is due to turbidity grading of minute silt and clay fractions. Note small fracture-filling quartz veins.

98.55 City limits of Norman, Arkansas. Formerly known as Womble, but when Mr. Womble left, the name was changed.

98.6 Banded shale and discontinuous sandstone of the Blakely Sandstone. Faults are exposed south of here in an exposure near school building.

99.0 LUNCH STOP! Hattie's Cafe to east serves the best in "home-cooked" food. Old courthouse to west (right).

Fold patterns start to change south of Norman, Arkansas. Most axial surfaces are moderately inclined and dip southeastward, though about a third of those measured in the area between Norman and Caddo Gap dip gently to the northwest. They appear to be gently warped about a northeast-southwest axis. Fold hinges consistently plunge eastward toward the Mazarn synclinorium though reclined hinges plunging south-southeast become more numerous toward the south. Indeed, the outcrops of novaculite at Caddo Gap provide the best examples of superposed folding in the western Ouachita Mountains. On the geological map a down-dip view of the Arkansas Novaculite-Stanley contact shows S rotations, but at Stop 2-11 a Z rotation has been superposed on the earlier folds. Axial surfaces of the S folds have been folded back toward the south. A reclined system has been noted in several localities almost as far west as the Oklahoma line. At Stop 2-9 we also see evidence of the older northward movement, which may well have been associated with sediment slide and gravity tectonics.

99.6 Northward dipping sandstone and banded shale of the Blakely Sandstone to south (right).

101.1 Banded shale and very thin sandstone of the Blakely Sandstone.

102.0 Northward dipping, upright (good bottom marks and graded bedding) shale and flaggy sandstone of the Blakely Sandstone. How can this geology be so straightforward?

103.3 Good exposure of Blakely shale and sandstone with two generations of folds and cleavage. Fold axes or cylinders on one fold system are nearly vertical. Notice lenticular sandstone mass at north end of roadcut.

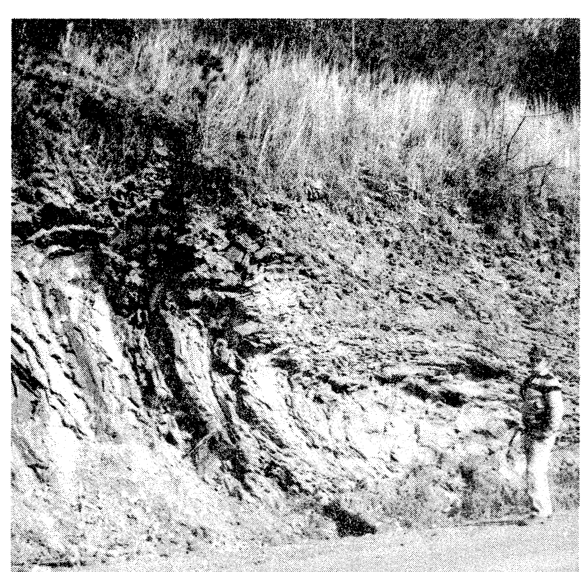
104.5 <u>STOP 2-8. (20 MINUTES) CONTACT BETWEEN BLAKELY SANDSTONE AND WOMBLE SHALE AT COLLIER CREEK. PARK SOUTH OF BRIDGE</u>.

Beneath bridge is a good exposure of thin-bedded, often graded, and bottom-marked sandstone and shale of the upper Blakely Sandstone.

Notice the many sedimentary features and only minor folds and cleavage. Graptolites occur in

Small southward overturned fold in banded slate and siltstone of the Mazarn - Stop 2-7.

George Viele standing by a lenticular sandstone mass in the Mazarn - Stop 2-7.



A rather intricate system of generally reclined folds in the thin bedded chert and siliceous dense limestone of the Bigfork at Caddo Gap, Arkansas - Stop 2-10.

some of the black shale of the lower Womble just south of the bridge. An intraformational breccia with limestone and siltstone clasts occurs in Womble on east side of road near parking area.

105.3 Post mill to west.

105.4 Contact between dense limestone and siliceous shale of Womble Shale (below) and calcareous chert of the Bigfork Chert to east.

105.45 City limits of Caddo Gap, Arkansas.

105.7 Downtown Caddo Gap, Arkansas, turn west onto gravel road across railroad tracks.

106.0 Low-water bridge over Caddo River. Notice swinging bridge to right, also exposures of very intensely folded, dense limestone and shale of upper Womble Shale. How about this for clear and cold spring-fed water!

106.25 Low, "potato" hummocky hills to south are formed by the Bigfork Chert, the higher ridges, with large talus slopes, are created by the Arkansas Novaculite. This is the Caddo Mountain subprovince.

106.5 Folded Bigfork Chert and siliceous limestone crops out on south side of road.

106.95 Junction, turn north on gravel road.

107.05 Interbedded dense limestone and shale of upper Womble Shale to east.

107.85 <u>STOP 2-9. (25 MINUTES) MELANGE IN UPPER WOMBLE AT MANFRED, ARKANSAS</u>.

Downstream east of the low-water bridge is one of the most exotic exposures in the central Ouachita Mountains. Thin to thick, dense limy siltstone, sandy limestone, chert and shale pebble, limy conglomerate, and shale with strong evidence for multiple periods of folding and faulting. One period of folding and faulting appears to be penecontemporaneous with deposition (sediment-flow) in form. A major fault separating Womble from Mazarn has been mapped just north of this Stop. Notice excellent cleavage, top and bottom indicators, quartz-calcite veins, slickenside zones, boudinage, and possible erratic materials. This occurrence is known as the Manfred melange. Much of the upper Womble in this region resembles this exposure.

Return to Caddo Gap, Arkansas.

109.95 Junction at Caddo Gap, turn south on Ark. Hwys. 27 and 8.

110.2 STOP 2-10. (15 MINUTES) FOLDS IN BIGFORK CHERT AT CADDO GAP.

At least two directions of folding are developed in this rucked sequence composed of thin chert, siliceous shale and decalcified siltstone of the Bigfork Chert. Note steep plunge on some of the folds and refraction of cleavage across various resistant layers. Good view of Caddo Mountains to south.

110.8 Bridge over creek.

110.85 - 111.15 STOP 2-11. (50 MINUTES) CLASSIC EXPOSURES OF ARKANSAS NOVACULITE AT CADDO GAP.

There are excellent outcrops of upper Missouri Mountain Shale (north end) with a thin chert-sandstone conglomerate bed; massive, dense, white to light gray, highly jointed, sometimes manganiferous, sometimes sandy in basal portions, Lower Division; black shale, and thin chert of the Middle Division; thin bedded to massive, cream to white tripolitic Upper Division of the Arkansas Novaculite; and shale, graywacke and thin chert-sandstone conglomerate of the lower Stanley Shale.

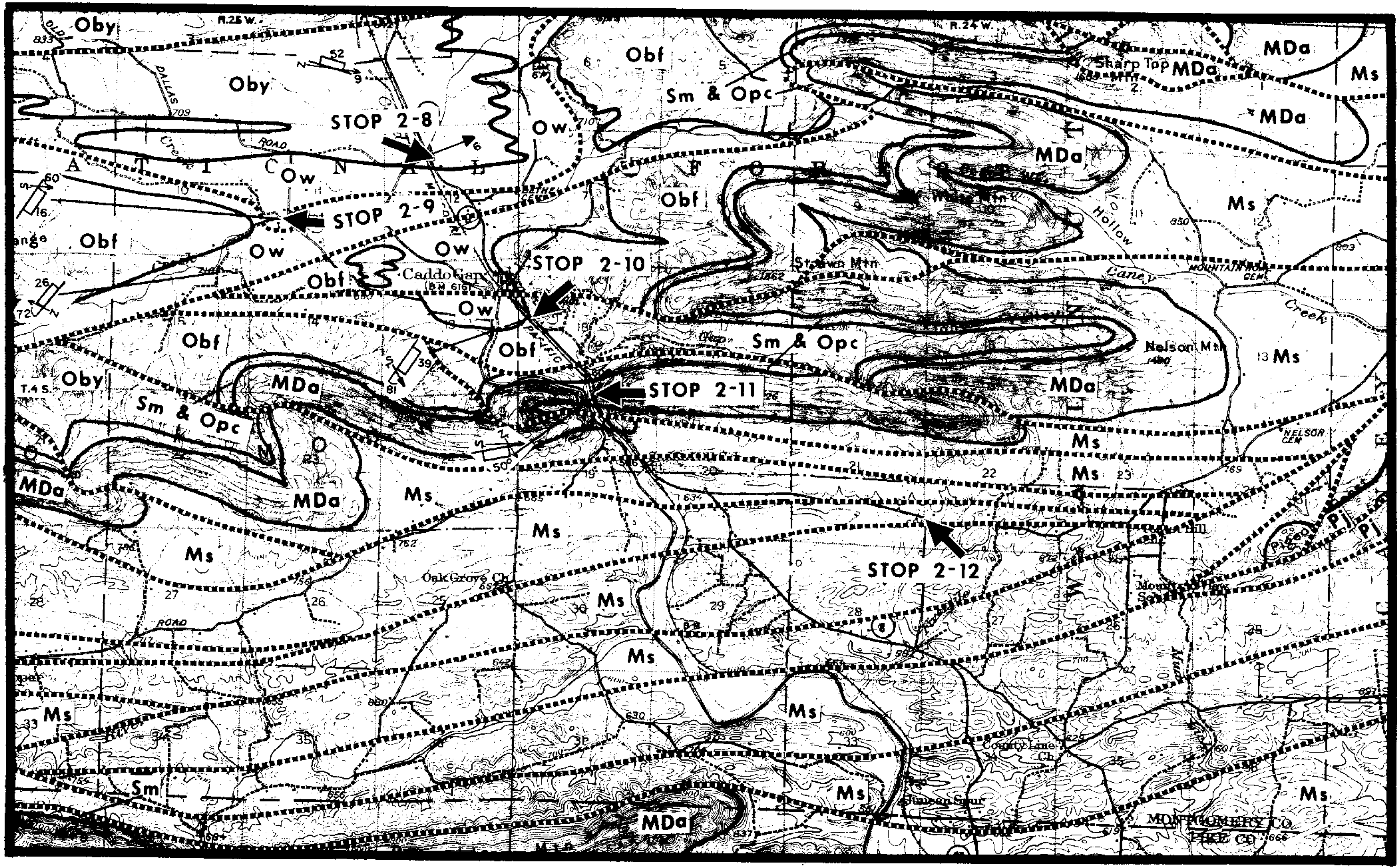


PLATE 21. GEOLOGIC MAP OF CADDO GAP, ARKANSAS AND VICINITY-
STOPS 2-8, 9, 10, 11, and 12.

1000 0 1000 2000 3000 FEET

Geology by Purdue and Miser, modified by Stone and Haley.

Excellent exposures of these units occur along the highway, railroad, and Caddo River both to north and south of stop area. Hass-AAPG (1951) placed the Mississippian-Devonian boundary on conodonts some 27 feet below top of Middle Division. Expecially note steep plunge of fold axes (cylinders) on one fold system. Another period of folding is much flatter in attitude. A thrust fault is present along southern margins of Stop. Small hot springs issue from exposures of massive novaculite in the river and along the west bank to the north.

Legend has it that DeSoto's party (1541) was attacked here by the Tula Indians who rolled boulders down the steep slopes.

Recent investigation by Albert Kidwell has disclosed a suite of rare iron phosphate minerals in an abandoned manganese mine in the Arkansas Novaculite near Albert Pike State Park some 18 miles to the west.

111.3 Contact of Arkansas Novaculite and Stanley Shale.

111.35 Junction with Ark. Hwy. 240, continue on Hwys. 27 and 8.

111.65 Alternating graywacke and shale in highly folded and faulted lower Stanley Shale.

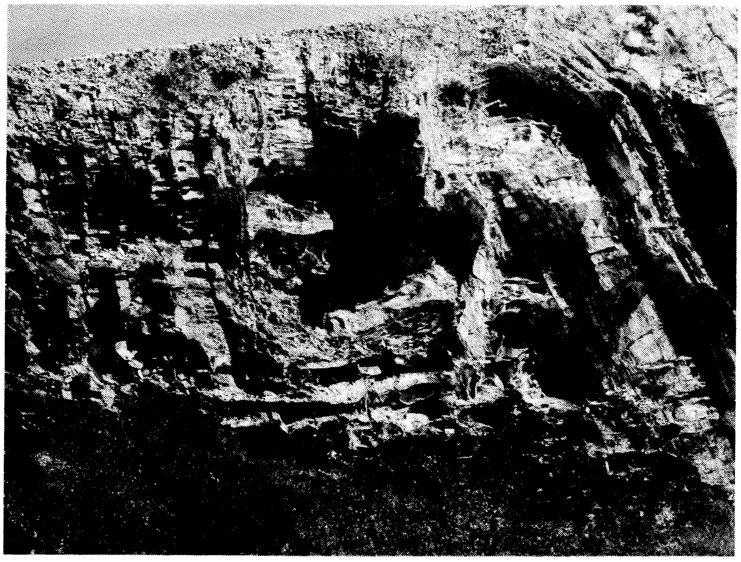
111.75 Bird and Son Roofing Granule Plant to west.

111.9 Turn to east off Ark. Hwy. 27 onto gravel road.

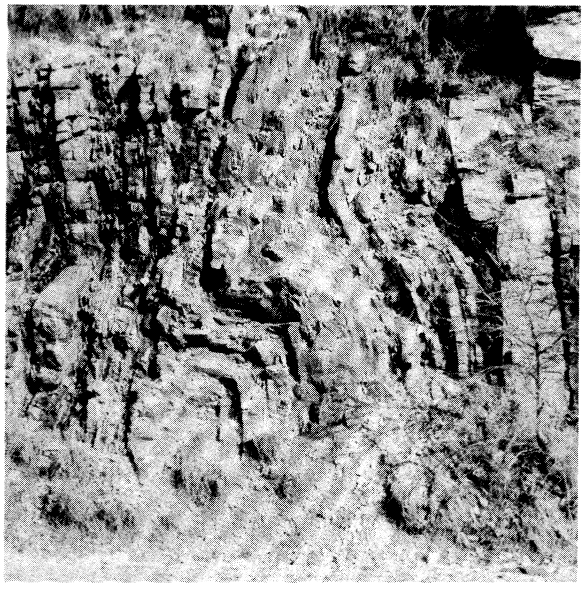
113.75 STOP 2-12. (20 MINUTES) BIRD & SON GRANULE PIT IN LOWER STANLEY SHALE.

Shale or slate in lower Stanley is being mined for roofing granules. This exposure of steeply southward-dipping, black shale and thin graywacke is cut by several thrust faults, with excellent broad polished slickenside (dickite, etc.) surfaces. Faulting has repeatedly shoved one sequence northward over another. The northward moving thrusts

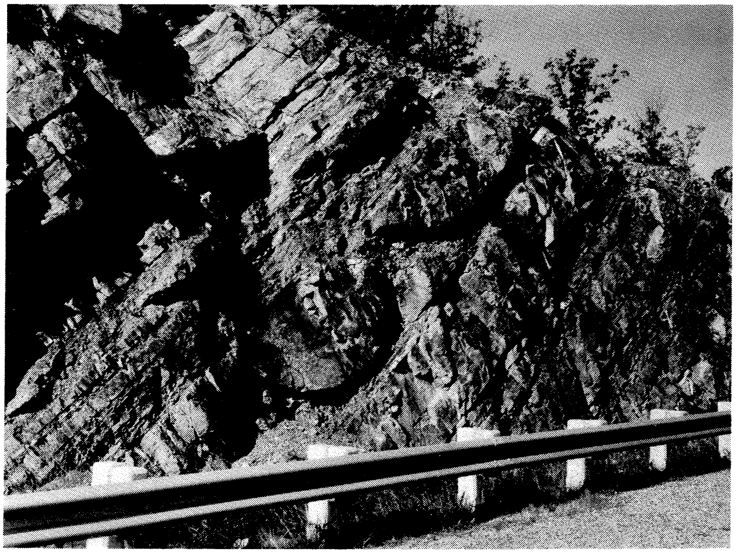
A fold standing nearly on "end" within the massive Lower Arkansas Novaculite at Caddo Gap. Note the small Fault breaching the sequence - Stop 2-11.



Another reclined complex fold in shale and thin novaculite in the Lower Division of the Arkansas Novaculite at Caddo Gap - Stop 2-11.



View of a convolute sandstone bed of the lower Jackfork that has moved in respect to the underlying shale. Note the rather uniform lithologic intervals above and below - Stop 2-14.



are slightly backfolded toward the south. Small quartz veins, with pyrite, fill fractures in the broken sandstone layers. Notice cleavage dipping both to the south and also some steeply to the north. Deposits of "bedded" barite occur locally in the Fancy Hill (west) and Pigeon Roost (east) Districts in the lower Stanley Shale. Scull (1958) considers the barite a hydrothermal deposit and relates it to Mesozoic intrusives; whereas Brobst and Ward (1965) ascribe a primary sedimentary origin.

Return to Ark. Hwy. 27.

115.6 Junction, turn south on Ark. Hwy. 27. Thrust faulted, steeply-dipping Stanley Shale is exposed for the next several miles in the western Mazarn Basin. Tall hills to the west are anticlinal mountains of Arkansas Novaculite, Blaylock Sandstone and older rocks of the Cossatot Mountain subprovince.

118.2 - 118.5 Good exposure of steeply-dipping, alternating graywacke and shale of the middle Stanley Shale.

119.2 Faulted, steeply northward-dipping, graywacke and shale of middle Stanley Shale.

119.3 City limits of Glenwood, Arkansas.

120.5 Downtown Glenwood, Arkansas. Junction Ark. Hwy. 27 and U. S. Hwy. 70B, turn west on Hwy. 70B.

120.9 Junction U. S. Hwys. 70 and 70B, turn west on Hwy. 70.

121.0 Bridge over Caddo River.

122.2 Sheared and faulted lower Stanley Shale to north.

122.8 View of faulted anticlinal ridges (Arkansas Novaculite) in all directions.

124.3 Intensely sheared shale of lower Stanley Shale in small creek to north.

124.5 STOP 2-13. (20 MINUTES) STANLEY-ARKANSAS NOVACULITE WEST OF GLENWOOD.

This fine exposure displays typical lower Stanley shale, siltstone and minor conglomerate; tripolitic, thin-bedded Upper Division; and black siliceous shale and chert of the Middle Division of Arkansas Novaculite. Notice folds overturned to north and the southward-dipping fault planes (which repeat portions of the sequence). In the Cossatot Mountain sub-province the underlying Blaylock Sandstone of Silurian age is about 800 feet thick and consists of interbedded thin sandstone, siltstone and shale with many flysch-like characteristics including abundant probable deep-water trace fossils.

124.6 Turn around and return to Junction with Ark. Hwy. 8.

128.1 Junction of U. S. Hwy. 70 and Ark. Hwys. 27 and 8, turn south on Hwy. 8.

128.3 Northward-dipping, lower Stanley graywacke and shale with steeply inclined thrust faults.

129.3 Shale, thin chert and conglomerate intervals of lower Stanley (Hot Springs Sandstone equivalent).

129.5 Bridge over creek.

129.7 Steeply-dipping Stanley shale and graywacke.

130.3 Southward-dipping Stanley shale and graywacke.

130.6 Rosboro, Arkansas. Several major faults occur in this vicinity - ridges to west are Jackfork Sandstone (locally along the northern border siliceous shales of the Chickasaw Creek Member of the upper Stanley are present) and some ridges to east are formed by Arkansas Novaculite.

132.7 Junction with Ark. Hwy. 84, continue on Hwy. 8. Exposure of weathered graywacke in lower Stanley Shale to south.

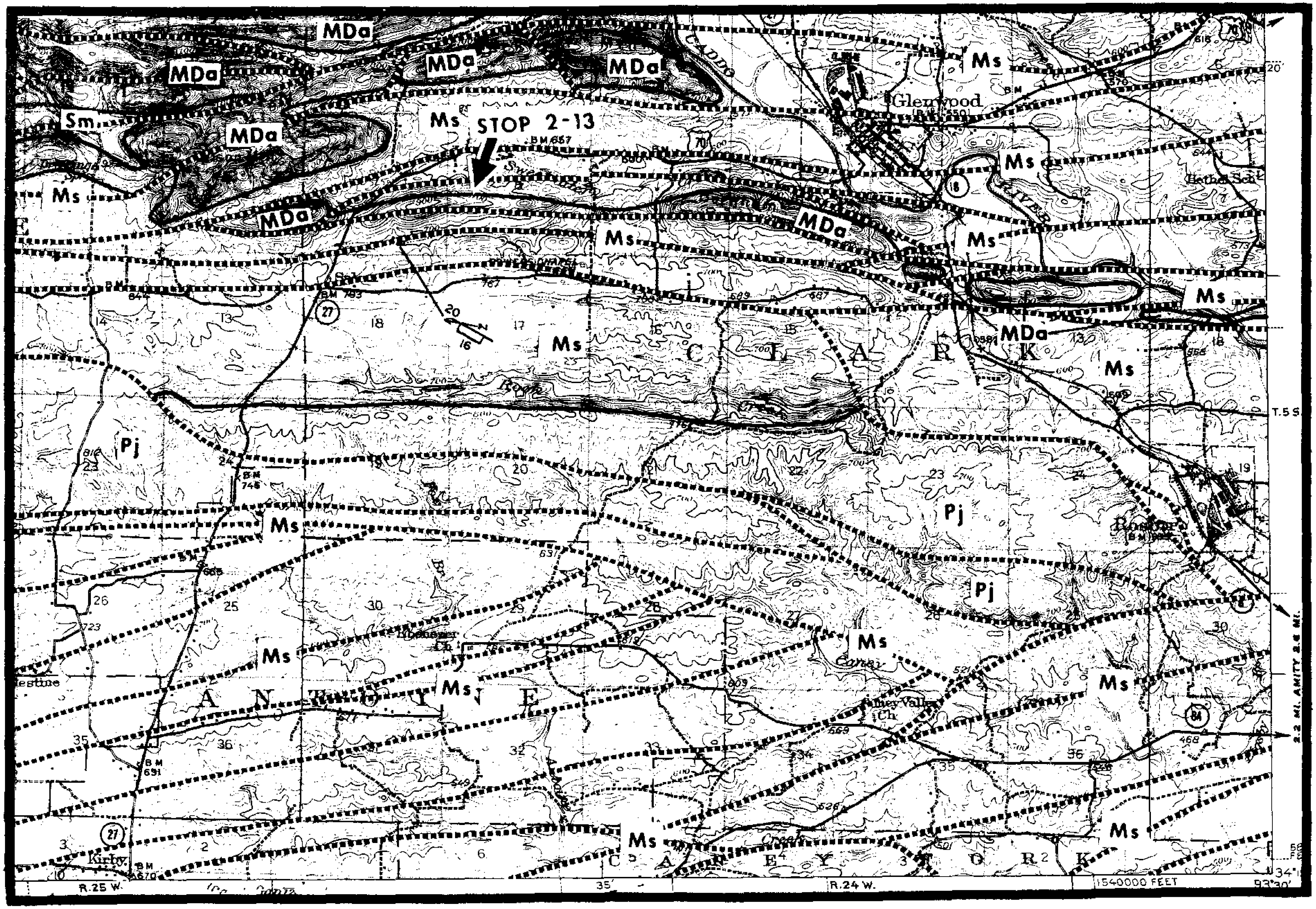


PLATE 22. GEOLOGIC MAP OF GLENWOOD-KIRBY, ARKANSAS-STOP 2-13.

1000 0 1000 2000 3000 FEET

Geology by Purdue and Miser, modified by Stone and Haley

133.45 Missouri-Pacific Railroad Crossing.

133.7 Lower Stanley at Amity, Arkansas. Sawmill to north, hill still farther to north is upper Arkansas Novaculite.

134.3 Square at Amity, Arkansas, proceed northeast on Ark. Hwys. 84 and 182.

134.6 Junction Ark. Hwys. 182 and 84, proceed east on 84 to Point Cedar and Bismarck, Arkansas.

137.5 Bridge over Caddo River and upper end of DeGray Lake. Faulted lower Stanley Shale crops out to east and north.

139.6 Northward dipping Stanley shale and graywacke.

140.5 Northward dipping shale and graywacke of the Stanley.

141.8 View of anticlinal and faulted Arkansas Novaculite ridge to north.

143.9 Enter Hot Spring County.

144.9 Dangerous narrow bridge! Exposures of Stanley Shale.

145.6 View of anticlinal Arkansas Novaculite ridge to north. Some smoky and water-bubble quartz crystals have been mined from this area. (Stroud, and others, U.S.B.M. Bull. 645, 1969)

146.1 Point Cedar, Arkansas. Poor exposures of lower Stanley Shale.

146.45 Junction with dirt road to north (see supplementary second day road log to abandoned Housley Lead-Zinc Mine - p. 111).

147.6 Narrow bridge! Note good exposure of Stanley Shale.

147.85 One lane bridge! Another good Stanley Shale exposure.

149.5 Old Landmark Missionary Baptist Church to south.

149.8 To east Stanley shale and graywacke dipping southward about 60°.

149.85 Stanley graywacke and shale to east.

150.0 Steeply-dipping Stanley graywacke and shale.

153.1 One lane bridge on outskirts of Lambert, Arkansas. Exposures of Stanley graywacke and shale to south.

153.4 Alternating ridges (sandstone) and valleys (shale) formed on large fold in the middle Stanley.

154.9 Bismarck, Arkansas. Steeply-dipping graywacke and shale of the Stanley.

155.4 Junction of Ark. Hwys. 84 and 7, proceed south on Hwy. 7.

155.6 Poorly exposed fault zone in Stanley graywacke and shale to east.

157.5 Southward dipping graywacke and shale of Stanley.

159.6 Junction with Ark. Hwy. 128, continue on Hwy. 7.

160.3 Bridge over creek.

160.4 Alternating feldspathic, somewhat quartzitic sandstone (some lumpy) and shale in the upper Stanley to left. Notice small folds and faults.

160.6 View of large man-made dike on DeGray Lake.

161.1 Poorly exposed fault zone in the upper Stanley Shale.

161.7 Excellent view of DeGray Lake to west. Several fault zones (containing dickite and thin quartz veins) in the upper Stanley shale and sandstones were exposed along this belt during excavation for dike. Some very thin siliceous shale was noted about two miles to the east in the uppermost Stanley Shale (probably the Chickasaw Creek Member).

161.75 Entering Clark County.

161.90 <u>STOP 2-14. (20 MINUTES) FLYSCH SEQUENCE IN LOWER JACKFORK SANDSTONE</u>.

Begin ascent to top of hill. Alternating massive to thin, fine- to medium-grained (locally some grit layers with crinoid fragments) graded, bottom marked, convoluted, sub-graywacke to quartzitic sandstone; rather soft sandy siltstone with coalified plant fragments; and gray to black shale (containing some small iron carbonate concretions) of the lower Jackfork Sandstone. These are rather typical "Ouachita" turbidite sequences. Bottom marks indicate the paleocurrent was generally from an easterly direction. Several bedding-plane and cross-faults, containing dickite and drusy quartz also dissect the exposure.

162.75 Gently southward dipping, gravels, marls and clays (locally lignitic logs) of the Upper Cretaceous Tokio Formation.

163.15 Junction; turn right (west) onto DeGray Dam Road.

163.75 <u>STOP 2-15. (35 MINUTES) MIDDLE AND UPPER JACKFORK SANDSTONE AT DEGRAY SPILLWAY</u>.

Proceed to east, then south across many excellent exposures of southward-dipping, alternating, thick to very thin intervals of gray, quartzitic sandstone, gray to black siltstone (with coalified plant fragments) and black shale in the middle and upper Jackfork Sandstone. Particularly in evidence are: various types of graded beds; intraformational (?) slump or slide intervals containing small sandstone cobbles, chert pebbles, iron carbonate concretions and other materials in a generally black shale "matrix"; sandstone "lumps"; small faults with milky quartz veinlets and slickenside surfaces containing dickite and traces of cinnabar. At the south end of the spillway are at least 15 cycles of grit deposition (locally containing some traces of invertebrate fossil remains) in a 200-foot sandstone sequence. Probable deep-water trace fossils are also fairly numerous.

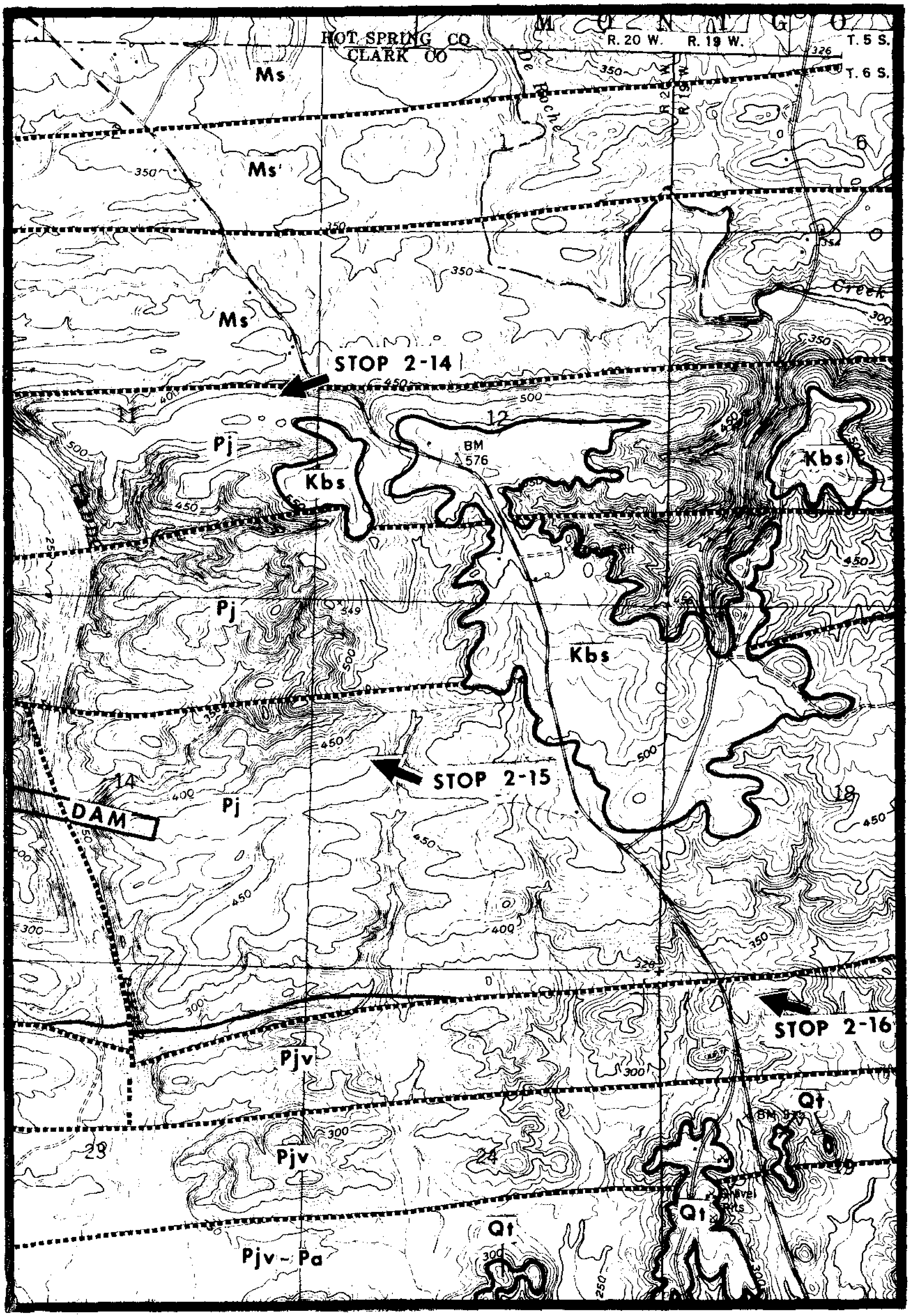


PLATE 23. GEOLOGIC MAP OF DeGRAY DAM AND VICINITY-STOPS 2-14,15, and 16,

1000 0 1000 2000 3000 FEET

Geology by Stone, Haley, Clardy and Bush

On the first day we saw evidence along the northern margin of the Ouachitas for northward tectonic transport. Here on the south side we see evidence for the same direction of movement; but in the Lower Paleozoics, we have seen abundant evidence of southward movement. This is one of the many Ouachita problems!

R. C. Morris has recently completed a detailed report on this exposure which will be published in its entirety at a later date in the Ouachita Symposium Volume. The following paragraphs and associated illustrations are extracts from this report.

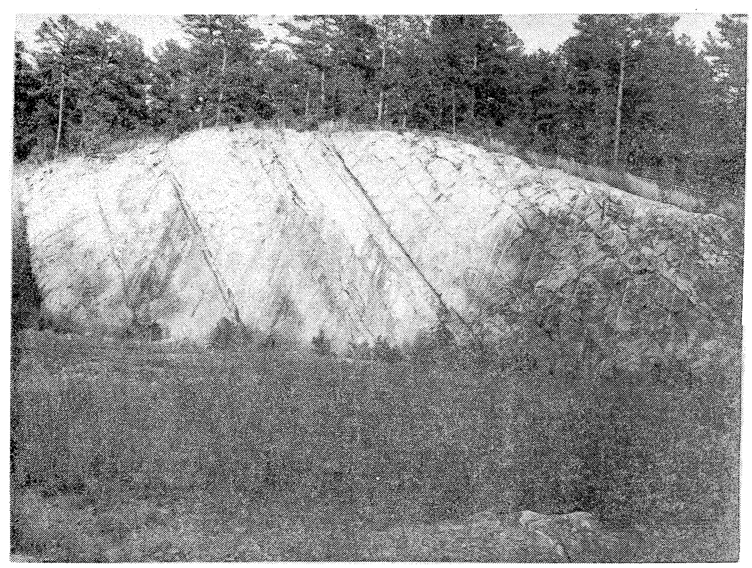
"The 1000-foot succession of upper Jackfork rocks exposed along the spillway at DeGray Dam provides a unique opportunity to study most types of Carboniferous flysch subfacies in the Ouachita Mountains. The following discussion is intended to extend to all Carboniferous rocks throughout the Ouachita Mountains, but the measured section (Fig. 3) and all illustrations used here come from the spillway section. Figure 2 is a conceptual model of the facies relationships. The facies symbols in Figure 2 are placed alongside the stratigraphic section (Fig. 3) to designate interpreted subfacies.

"In Figure 2 each major facies is represented by number, whereas letters designate subfacies. The facies subdivisions of the measured sections illustrated in this report are designated by these numbers and letters. Sediment entered the basin in three ways: (1) by settling out from suspension to form the pelagic facies, (2) by slumping or sliding to form the disturbed beds, or (3) as turbidity currents. Downslope from their point of origin, proximal turbidites pass into distal turbidites with the very fine material in suspension carried still further to form the pelagic facies. Each facies can be subject to soft-sediment deformation within the basin.

Wildflysch interval in a uniform turbidite sequence, containing small sandstone pebbles and siderite concretions in the upper Jackfork Sandstone at the DeGray spillway. Stop 2-15.

Close-up of the wildflysch interval. Note the sharp contact of the overlying sandstone - Stop 2-15.

A thick sandstone sequence of the upper Jackfork at the south end of the spillway exposure. Notice that there are thin shale beds in the interval - Stop 2-15.



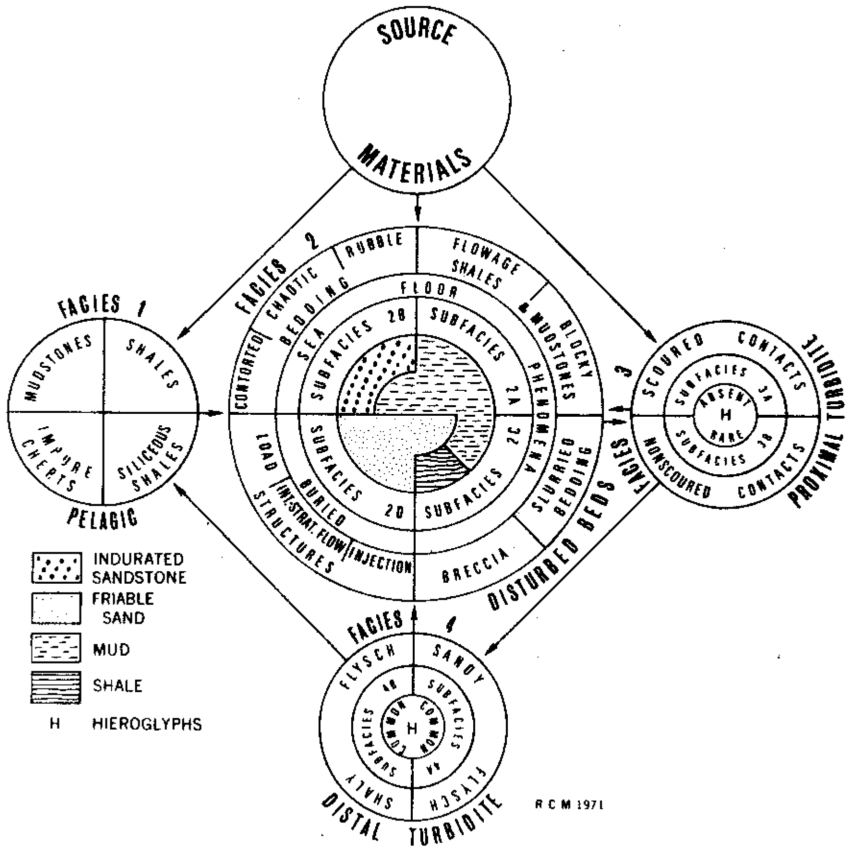


Figure 2. Conceptual model of major facies relationships (R. C. Morris).

Names around the outer edge of the diagram for Facies 2 suggest the types of disturbed bedding to form, dependent upon type of lithology involved (center of diagram).

"The Jackfork sandstones display a wonderful array of sole markings that can be utilized to reconstruct ancient paleocurrent directions. Flute casts and prod casts impart a current direction sense only. Figure 5 is a summary diagram of upper Jackfork paleocurrents in the general area of the spillway. The mean direction of 274° is very close to a grand mean of 266° obtained from 141 upper Jackfork readings. Although not readily apparent on this diagram, there is evidence that the sands entered from two point sources. Non-feldspathic detritus entered from the northeast, whereas sparsely feldspathic detritus entered from the southeast. Down the axis of the trough to the west, the number of sands increased, the thickness of each sand decreased, and a broad, abyssal plain was formed.

"The rocks of the spillway section apparently were deposited upon an ancient abyssal plain not far removed from a continental rise. The dominant pattern of sedimentation was repetitive incursions of turbidity flows whereas minor slumping also contributed to the development of the sedimentary succession. The more powerful turbidity currents, presumably initiated from nearby areas, were capable of carrying tremendous quantities of sand which eroded and scoured significant portions of underlying beds before depositing their load. Natural groupings of such deposits can be called proximal turbidites. Other less frequent, less turbulent currents, perhaps originating from more distant points, developed patterned scours and tool marks over cohesive mud bottoms. The repetitive nature of these turbidites and muds form a natural grouping of distal turbidites. By giving empirical classifications such as proximal or distal turbidite to these abnormally thick turbidite

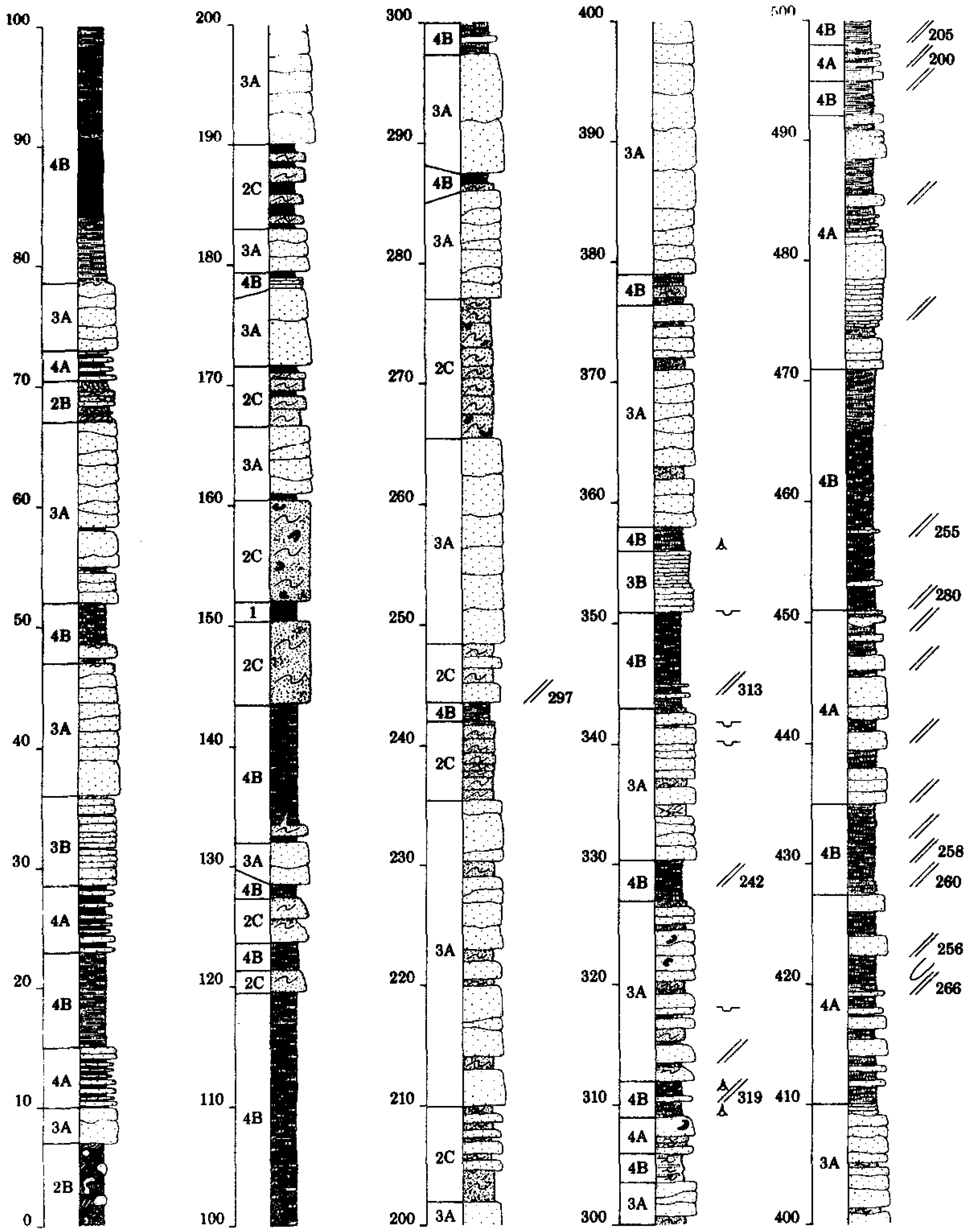


Figure 3. Partial stratigraphic section of upper Jackfork rocks exposed along the spillway at DeGray Dam, sec. 14, T. 6S, R. 20W. See figure 4 for legend. Numbers at left of each column are feet above bed where study began. Numbers and letters within central column are flysch subfacies designated in Figure 2 (from R. C. Morris).

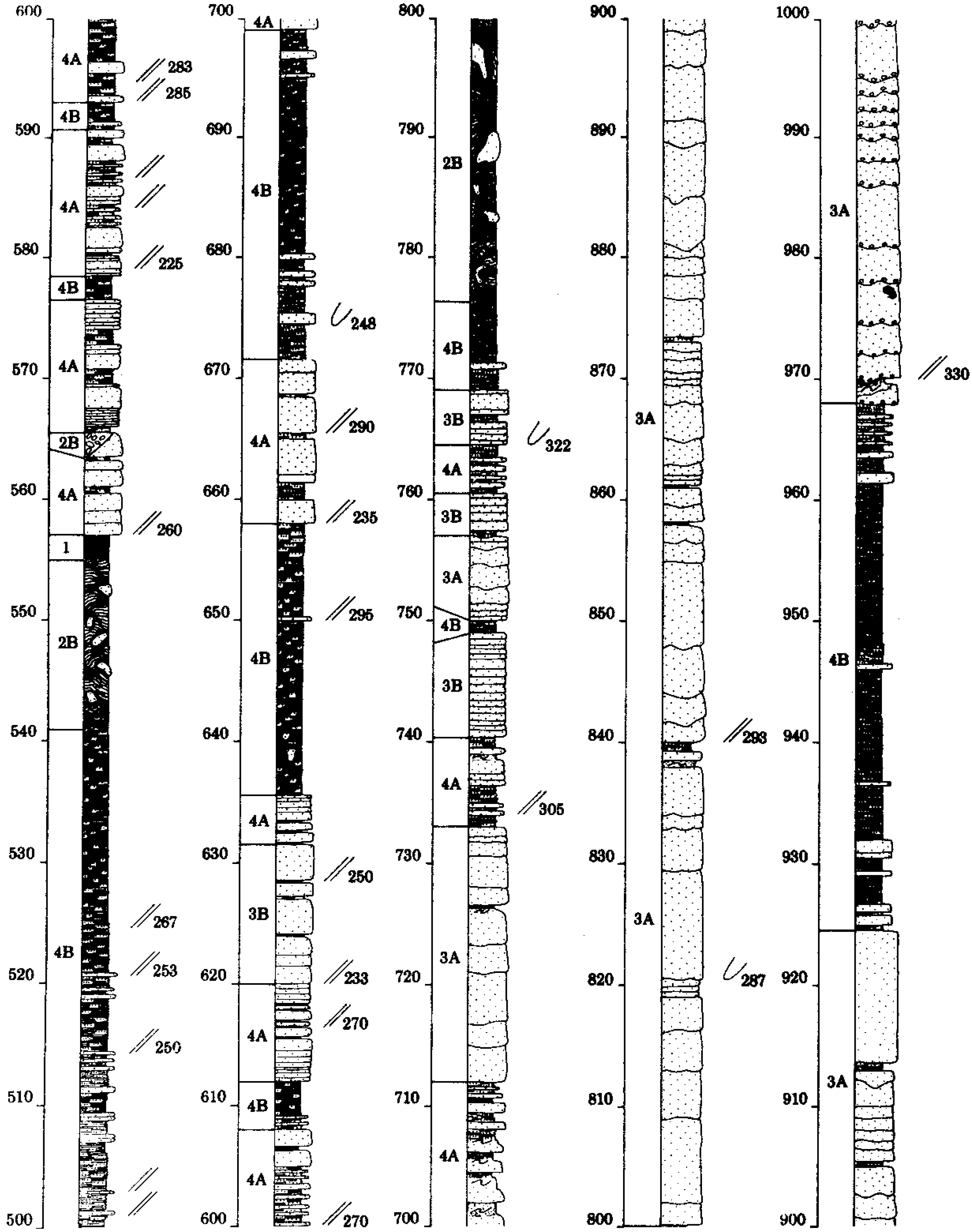


Figure 3. (Continued)

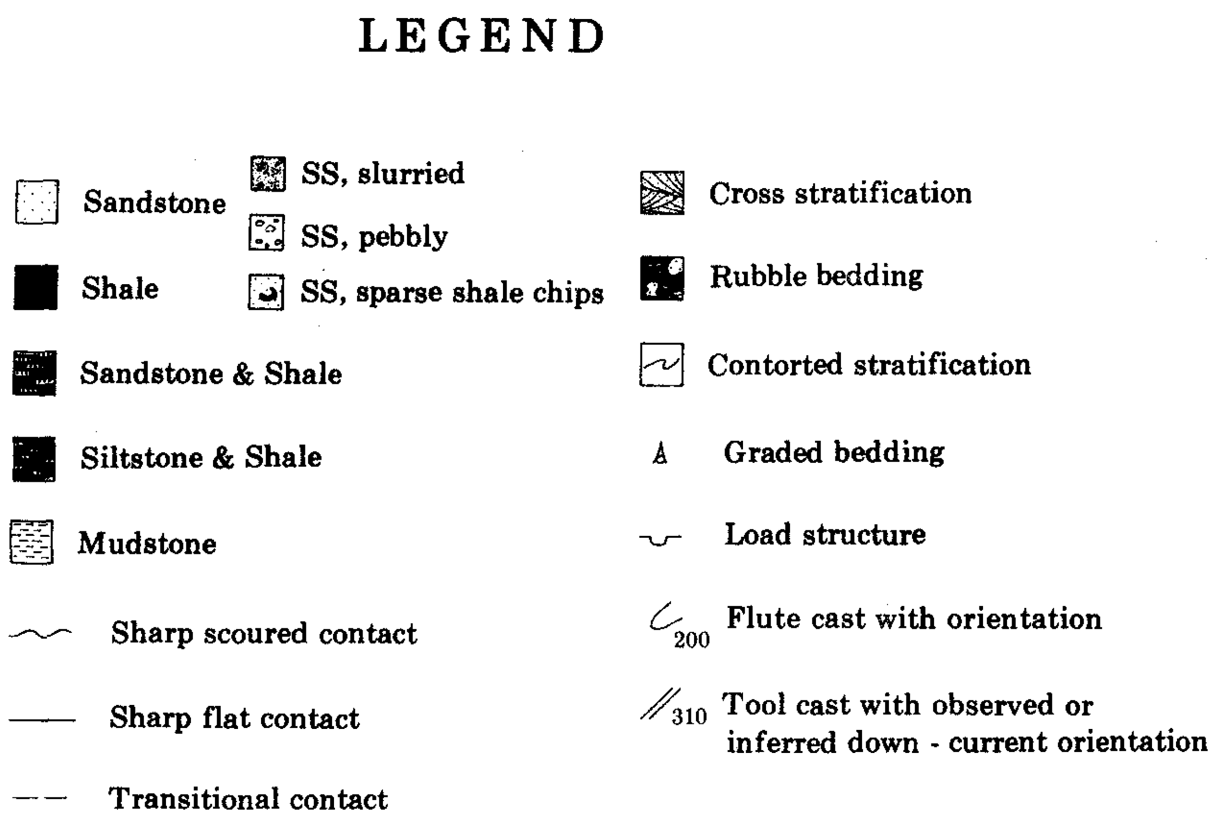
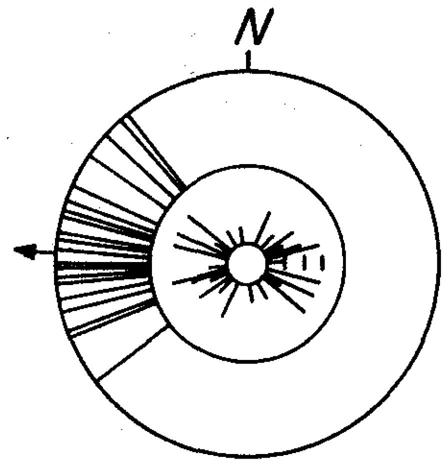


Figure 4. Legend for lithologies, bedding contacts, and sedimentary structures in the stratigraphic section (R. C. Morris).



LOC. 21, T 6 S, R 20 W
N = 44, $\bar{X}$ = 274°

Figure 5. Paleocurrent diagram of sole marks from Upper Jackfork sandstones in the spillway area. Inner circle indicates data with current trend only (length of lines correspond with number of readings); outer circle includes current directions from prods or flutes. Arrow indicates mean current direction as determined from all measured or inferred down-current directions. Letter N indicates north (from R. C. Morris).

successions, we estimate how "proximal" or how "distal" one or more point sources may have been located. A complicating factor is that different volumes of material were dislodged at different times. In conclusion, thick sequences of proximal turbidites probably did originate nearby and thick sequences of distal turbidites probably had a more distant beginning. Close vertical stacking of these two end members could either be due to dovetailing of turbidites from two or more point sources, or to differences in sedimentary volume resedimented or both."

164.5 A beautiful view of DeGray Dam and Lake on the Caddo River. Notice excellent exposures of southward-dipping middle Jackfork sandstone and shale to the west. A small cross fault occurs below dam on the east side. Return towards Ark. Hwy. 7.

165.85 Junction; turn right (south) on Ark. Hwy. 7.

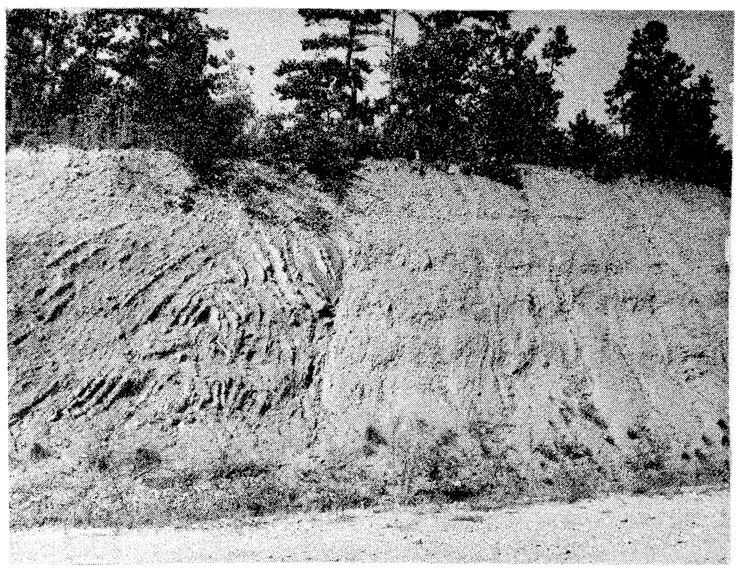
166.25 Junction of Ark. Hwy. 7 and 287, continue south on Hwy. 7.

166.55 Contact between Jackfork Sandstone and Johns Valley Shale.

166.65 Turn to east (left) onto dirt road.

166.75 STOP 2-16. (15 MINUTES) JOHNS VALLEY SHALE.

This entire exposure is in the Johns Valley Shale, the north end of the exposure being a few hundred feet from the contact with the underlying Jackfork Sandstone. Start at the north end of the exposure and proceed through southward-dipping, alternating massive-to-thin, silty, micaceous subgraywacke; sandy, micaceous punky siltstone; and silty shale. Locally, probable deep-water trace fossils are abundant in the sequence. There are some excellent sedimentary slump features and



A complex fold of probable sedimentary slide origin with an indicated translation of movement to the right (north) in the Johns Valley Shale - Stop 2-16.

also some later tectonic fault planes containing dickite. Walthall (1966-1967) restricted the Johns Valley Shale in the Athens Plateau to the 150-300 feet of black shale with siderite concretions lying immediately above the Jackfork Sandstone and he would probably include this outcrop in the lower Atoka. Microfauna collected from some of the concretions were indicated as Morrowan in age by Walthall (1966).

168.45 Junction of Interstate Hwy. 30; drive under overpass and proceed northeast on Interstate.

169.4 Poor exposures of nearly flat-lying Tokio gravel and clay of Upper Cretaceous age.

171.4 Contact of Jackfork Sandstone and Johns Valley Shale to north.

171.5 Hot Spring County line.

173.1 Good exposures of southward-dipping, lower Jackfork sandstone and shale.

173.7 Small exposure of probable Upper Cretaceous Tokio gravel and clay.

174.4 Concealed fault separating Jackfork Sandstone from Stanley Shale.

174.6 Bridge over creek.

175.0 Rather disturbed southward dipping, somewhat lumpy, sandstone and shale of Stanley Shale to west.

175.6 Bridge over creek.

175.9 Steeply-dipping, disturbed upper Stanley sandstone and shale to right (east).

176.7 Fine exposure of vertically dipping (top to north) lower Jackfork sandstone and shale. Notice small faults disrupting sequence.

177.6 Concealed thrust fault separating Jackfork Sandstone from Johns Valley Shale.

178.2 Nearly vertical strata at contact of Jackfork Sandstone and Johns Valley Shale.

179.1 Approximate contact between vertically dipping Jackfork Sandstone and Stanley Shale.

180.9 Bridge over creek with some poor exposures of faulted lower Stanley Shale.

182.2 Social Hill, Arkansas exit.

183.0 Bridge over creek.

184.2 Rest area to west.

184.55 Notice bump in road; this is contact between gravel and sand of a high Terrace or of the Wilcox Group (Eocene) above and marl and fossiliferous limestone of Midway Group (Paleocene) below. The Midway clay and marl is definitely a foundation hazard in this region!

186.9 Midway marl, clay, limestone and fossiliferous chert were nicely exposed at this locality where a large segment of roadway detached and slid eastward into the Ouachita River during road construction, causing much consternation and costly repairs. Notice there is now a sway in the roadbed!

187.6 Junction of Ark. Hwys. 84 and 171; continue on Interstate 30.

188.2 Bridge over Ouachita River. Steep spines of resistant Arkansas Novaculite are exposed in places in river bed.

188.5 Exposure of flat-lying, highly fossiliferous, Midway marl and limestone to north.

188.6 U. S. Hwy. 270 and Ark. Hwy. 51 overpass, continue on Interstate 30. Exposure of massive Lower Arkansas Novaculite in small creek to north.

188.7 Flat-lying, fossiliferous Midway marl to south. This is the Fall Line separating the Mississippi Embayment from the Ouachita Mountains.

190.4 Sand pit in the Wilcox Group to west.

191.0 Poor exposure of Midway marl to east.

191.7 Crossing bridge over Chicago-Rock Island Railroad.

194.2 At bridge over creek, steeply dipping, massive, white, Arkansas Novaculite capped or draped by Wilcox sand and clay. Notice Midway is locally missing!

195.2 Bridge over creek.

196.1 Saline County line.

196.3 Exposure of steeply dipping Arkansas Novaculite in road metal quarry to west capped or draped by Midway marl, limestone and gravel, and locally Wilcox sand and clay.

197.2 Small kaolinitic clay pit in Wilcox to east.

199.1 Poor exposures of Midway fossiliferous limestone and marl.

200.3 Nearly 20 feet of flat-lying, poorly consolidated deposits of Cretaceous-Paleocene Arkansas Novaculite and other Paleozoic boulders, cobbles, pebbles and clayey silt are poorly exposed to south.

200.9 Poorly exposed fossiliferous Midway marl and clay with some reworked Arkansas Novaculite boulders to west.

201.4 Interchange of Interstate 30 with U. S. Hwy. 70. Follow I-30 into Little Rock. See second day road log mileage 28.3 to 01.1 for outcrop descriptions.

228.6 Leave Interstate 30 at 6th Street Overpass. Poor exposures of Wilcox sand and gravel and some Terrace material.

228.7 Turn west (left) at stoplight onto 6th Street.

228.9 You are traveling in a portion of the old "well-to-do" part of Little Rock. General Douglas McArthur was born three blocks south of here at McArthur Park.

229.2 Main Street in Downtown Little Rock, Arkansas.

229.5 Broadway Street, continue on 6th Street.

229.6 Turn right (north) on South Gaines Street.

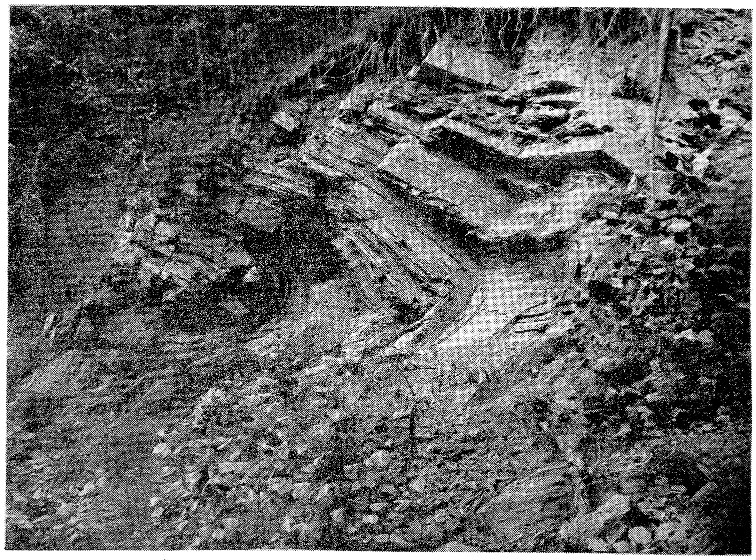
229.7 You are there! SAM PECK HOTEL, Little Rock, Arkansas.

SUPPLEMENTARY SECOND DAY ROAD LOG

CRYSTAL MOUNTAINS AT COLLIER SPRINGS VIA LOGAN GAP ROAD AND FOREST TRAIL 177

MILEAGE	DESCRIPTION
(84.5)	
0.0	Junction with Logan Gap gravel road to south, at mileage 84.5 of the second day road log. Some intensely cleaved Womble shale crops out to west (right).
0.75	STOP 2a-1. BLAKELY SANDSTONE AND FOLD This is a rather spectacularly folded exposure of quartzitic, often calcareous, flaggy to fairly massive sandstone and thin interbedded siltstone and shale of the Blakely Sandstone. There are various opinions (sedimentary or tectonic) concerning the origin of structures near middle of exposure. The sandstone of the Blakely in this area and to the west are somewhat discontinuous, generally forming only small ridges and thus creating some problems in stratigraphic determinations between Womble—Blakely—and Mazarn Formations.
1.55	Exposure of gently southward dipping Womble shale and weathered calcareous siltstone with numerous dissecting milky quartz veins to east (left). Several very large, low-angle, folded faults occur in this area.
2.35	Road to right leads up Fisher Mountain where excellent, clear, quartz crystals have been mined for many years along several quartz leads in the often decalcified Crystal Mountain Sandstone. Some fresh exposures of the Formation occur in Twin Creek to east (left).
2.65	Road Junction with U. S. Forest Trail - turn right (west).

2.75	Road Junction - continue right on U. S. Forest Trail 177 to Collier Springs.
2.95	Small exposure of Collier shale and thin, dense limestone to south in small creek.
3.25	A small spur formed by Crystal Mountain Sandstone to south, roadbed is underlain by Collier Shale.
4.0	Massive blocks of Crystal Mountain Sandstone to south.
4.25	A view of Fisher Mountain Spur to north with several quartz crystal mines in Crystal Mountain Sandstone.
4.35	A typical hilltop exposure of the very massive, quartzitic Crystal Mountain Sandstone (south dipping).
5.25	Massive Crystal Mountain Sandstone crops out to right. Look closely and you can see the interbedded shale.
5.6	More good crops of the massive Crystal Mountain sandstones.
5.65	Road junction, turn south (to left) to Collier Springs.
5.85	Crystal Mountain Sandstone on right.
6.35	Crystal Mountain Sandstone on right.
6.65	Exposure of steeply-dipping and folded, massive Crystal Mountain Sandstone to east.
6.95	East-west valley formed by shale and siltstone of the Mazarn which are nicely exposed in a small pit some 0.2 miles to west (along small trail).
7.05	Good exposures of massive sandstone (some decalcified), and shale of Crystal Mountain Sandstone.



This southward overturned fold occurs in the Blakely Sandstone - Stop 2a-1.

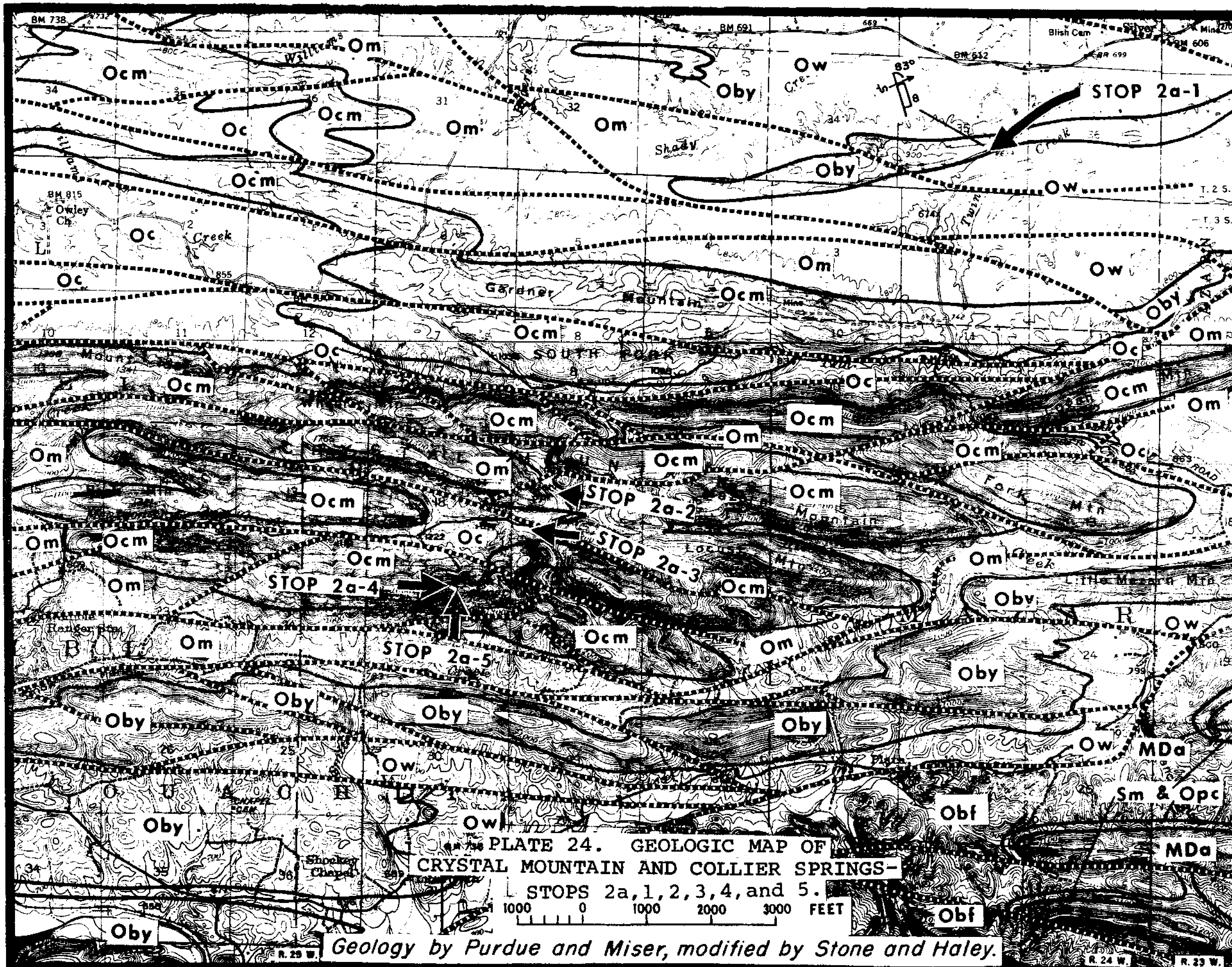


PLATE 24. GEOLOGIC MAP OF CRYSTAL MOUNTAIN AND COLLIER SPRINGS- STOPS 2a,1,2,3,4,and 5.

Geology by Purdue and Miser, modified by Stone and Haley.

7.15 STOP 2a-2. COLLIER SPRINGS.

A truly excellent quality, cool spring water gushes from cavities in the massive slightly calcareous sandstone of the Crystal Mountain to the west of the road in and along Collier Creek. The water issuing from large spout is only a portion of the flow. Notice water-cress and other plant forms.

7.25 Lichen coated bluff to east formed by massive Crystal Mountain sandstone. Notice large-leafed trees; these appear typical of creeks cutting exposures of Crystal Mountain Sandstone and Collier Shale (limestone).

7.45 Approximate contact of Collier Shale with the Crystal Mountain Sandstone.

7.75 STOP 2a-3. PELLETOIDAL COLLIER LIMESTONE.

In Collier Creek there are many excellent fresh exposures of intensely folded, flaggy to massive, gray, dense, finely crystalline, often pelletoidal or oolitic, pyritic?, limestone; with interbedded black, "talcose", shale; and some very small, black, flint lenses. Several sedimentological questions have arisen on these deposits. Is this a shallow-water deposit? If not, did pelletoidal material slide into a deeper trough? Or, can material of this nature form in deep water?

7.95 - 8.1 One-lane bridge. The Collier Shale makes many fine exposures along the creek.

8.45 Junction of U. S. Forest Trails 177 and 177K. Turn left on 177K. This is a rough, crooked, and steep road.

8.47 Exposures of Crystal Mountain Sandstone.

9.45 STOP 2a-4. HIGH PEAK QUARTZ CRYSTAL MINE.

Some very beautiful, clear, quartz crystals, often coated by various manganese and iron minerals were mined here in 1970 from cavities in fairly wide veins dissecting the massive southward dipping (upright) Crystal Mountain Sandstone. These crystals can be obtained from many of the local mineral dealers.

9.47 STOP 2a-5. HIGH PEAK OVERLOOK AND TOWER.

Wildness and ruggedness at its best! From this spot on clear days one can see much of the heavily forested, rugged landforms of the surrounding Crystal Mountains.

To the southwest the Caddo and, occasionally, the Cossatot Mountains are visible. In the distance to the north and northeast of Lake Ouachita the frontal belt of the Ouachita Mountains can often be seen protruding into the clouds.

Return to Road Junction.

10.67 Turn west (left) onto U. S. Forest Trail 177.

11.35 Collier Shale on right.

12.2 Collier limestone and shale on right.

12.55 Crystal Recreation Camp grounds on left.

12.95 Contact of Crystal Mountain Sandstone and Collier Shale to north.

13.05 Fairly good exposure of Crystal Mountain Sandstone along faulted anticlinal nose to north.

13.75 Nearly vertical, crinkled, banded shale and siltstone of Mazarn Shale to north. A very old, moss covered, concrete culvert in stream below was once mistaken by a geologist as a "Mazarn conglomerate".

14.95 Southward dipping, cleaved and folded, banded shale and siltstone of Mazarn in creek bed to south of bridge.

15.55 Junction with Ark. Hwy. 27. You are at Second Day Stop 2-7 (98.1 mi.) in the Mazarn Shale.

SUPPLEMENTARY SECOND DAY ROAD LOG

ABANDONED HOUSLEY LEAD-ZINC MINE

MILEAGE	DESCRIPTION
(146.45)	
0.0	Proceed north on dirt road (at mileage 146.45 of the second day road log).
0.55	Some poor exposures of steeply southward-dipping lower Stanley shale and graywacke.
1.05	Poorly-exposed southward-dipping Stanley Shale.
1.4	Junction, proceed east (right) on dirt road.
1.45	Crossing, clear and cool spring fed creek issuing from Arkansas Novaculite which crops out to north. This is the southwestern portion of the Trap Mountains sub-province. Proceed on trail to east (right).
1.55	Gently-dipping lower Stanley Shale in road.
1.70	STOP 2b-1. HOUSLEY (POINT CEDAR, PRICE-WILLIAMS) LEAD-ZINC MINE.

Galena, sphalerite, chalcopyrite and pyrite occur in three steeply southward-dipping milky quartz veins that occur in a thrust faulted sequence of probable Lower Arkansas Novaculite and lower Stanley Shale. The ore minerals assayed about 4 ounces of silver per ton and trace amounts of gold. The deposit was discovered in the 1890's and worked several years through shafts along a surface distance of about 210 feet.

The shaft at the east end of the old mill, which has recently burned, was some 127 feet deep with several drifts and stopes above the 82 and 110 foot levels.

Data in part from Stroud and others (U.S. Bureau of Mines, Bull. 645, 1969.) and R. B. McElwaine (written communication).

3.4 Return to Ark. Hwy. 84.

Junction with Ark. Hwy. 84 (146.45 mi.); turn to east (left).

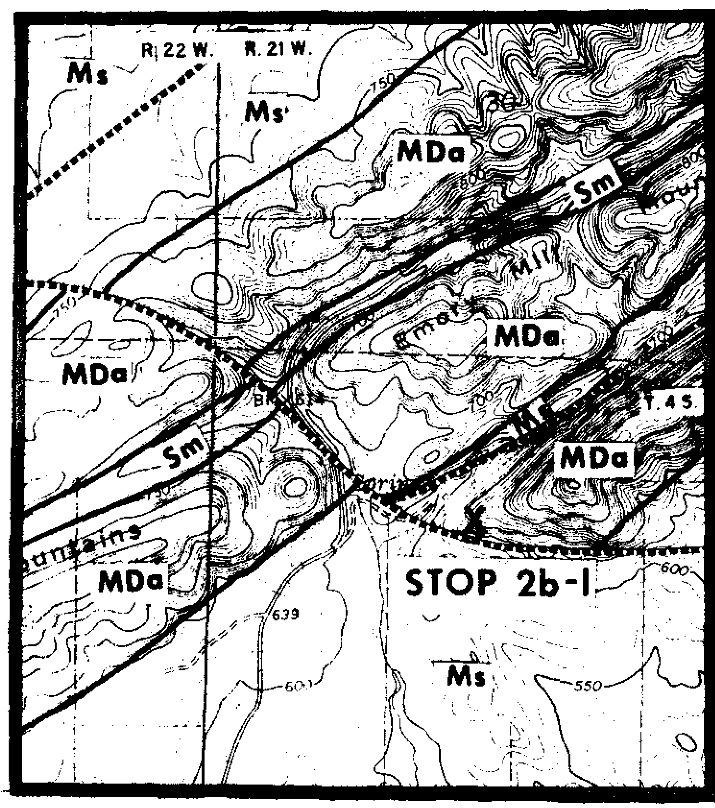


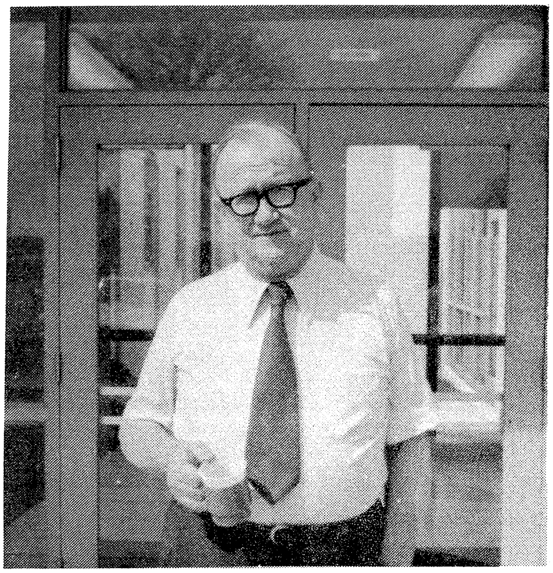
PLATE 25. GEOLOGIC MAP OF HOUSLEY MINE NEAR POINT CEDAR, ARKANSAS-STOP 2b-1.

1000 0 1000 2000 3000 FEET

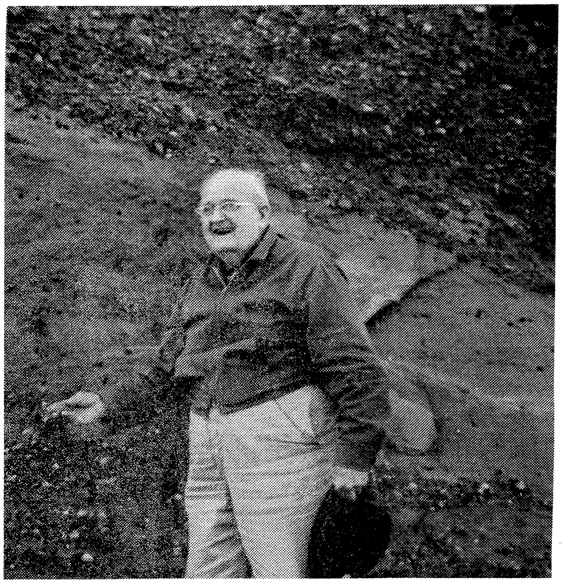
Geology by Woodward, Stone, and Haley

SOME MAJOR CONTRIBUTORS TO THE "NEW ERA" OF

GEOLOGICAL STUDIES IN THE OUACHITA MOUNTAINS, ARKANSAS

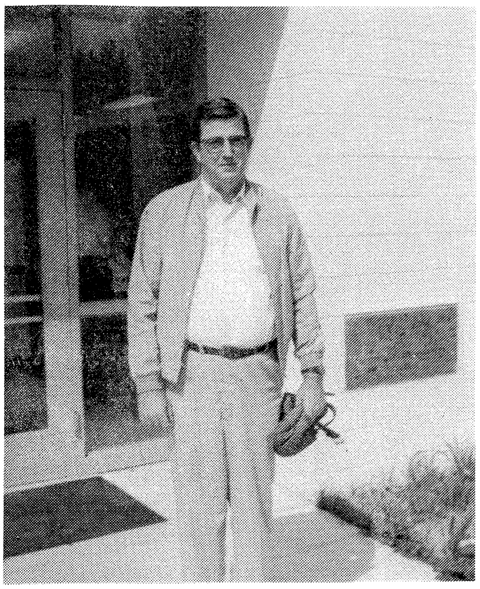


Norman F. "Bill" Williams
(Winter 1972-73)



Hugh D. Miser
(Fall, 1968)

Charles G. Stone, Drew F. Holbrook,
Philip J. Sterling (Spring, 1960)



Boyd R. Haley
(Winter, 1972-73)