TERTIARY SEDIMENTARY AND VOLCANIC ROCKS OF SOUTH-CENTRAL YAVAPAI COUNTY, ARIZONA

By

Charles St. Clair

ABSTRACT

South-central Yavapai County is part of a large area of Precambrian crystalline rocks discontinuously covered by thick deposits of volcanic and sedimentary rocks. The younger rocks comprise sequences of middle(?) Tertiary volcanic flows, conglomerate, sandstone, siltstone, and tuffaceous sandstone. Dissected gravel and terrace deposits and alluvial fans rest with erosional unconformity on Tertiary rocks.

The terrestrial sedimentary deposits and a few interbedded volcanic flows of probable middle Tertiary and Pliocene age were laid down in basins developed by deformation involving Precambrian rocks. The original thicknesses of the Tertiary deposits may have been in excess of a few thousand feet, but they have been extensively eroded.

The Tertiary deposits in the Walnut Grove basin on the west side of the Bradshaw Mountains, the Milk Creek beds, consist of about 2, 500 feet of fluviatile and lacustrine sediments, interbedded with several layers of tuff and a basalt flow. The upper 300 to 400 feet of these deposits is lower Pliocene (Clarendonian) in age, on the basis of a vertebrate fossil assemblage; the complete sequence is assumed to be lower Pliocene or Miocene and Pliocene in age.

The Rock Springs beds are about 30 miles southeast of the Milk Creek beds and on the east side of the Bradshaw Mountains. The Rock Springs beds total about 1, 100 feet in two discontinuous sections; they include volcanic flows, tuffaceous and clastic sandstone, and conglomerate. No fossils are known from the Rock Springs beds; however, these beds are lithologically similar to the Milk Creek beds and probably represent generally contemporaneous deposition in separate basins.

The Rock Springs beds are nearly horizontal and the Milk Creek beds dip moderately to the north and northeast, having been deformed by normal faults.

Arizona Geological Society Digest, Volume V, November 1962
Symposium on Cenozoic Geology of Arizona

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INTRODUCTION

Cenozoic sedimentary and volcanic rocks are widely distributed in south-central Yavapai County. They are critically situated in regard to any consideration that involves the relationships of the Colorado Plateau and Basin and Range provinces during Cenozoic time. This report presents some new data regarding the Cenozoic rocks in this area and outlines some of the general problems regarding them.

South-central Yavapai County lies within the central part of the mountain region, an area of irregular mountain masses and intermontane valleys between the Colorado Plateau and the Basin and Range provinces (fig. 5. 1). The Bradshaw Mountains lie in about the center of the area and the plains of Lonesome Valley separate them from the Black Hills. The New River Mountains are southeast of the Bradshaw Mountains and are separated from them by a dissected plateau cut on lava flows. To the west are the Weaver Mountains, separated from the Bradshaws by the Walnut Grove basin.

The Bradshaw Mountains, mainly a series of broad ridges trending north to north-northwest, are dissected by streams that drain generally southward. The Hassayampa River drains the western slopes and the Agua Fria River the eastern slopes. Physiographic development is related to the structure and lithology of the underlying rocks.

In general, the rocks of the mountain region are uplifted relative to the Colorado Plateau to the northeast and the Basin and Range province to the south and southwest. The region is composed of crystalline Precambrian rocks, covered in part by Cenozoic volcanic and sedimentary rocks. Paleozoic and Mesozoic rocks do not appear in the area but crop out to the north and northeast in the vicinities of Jerome and Camp Verde. The complexity of lateral variation within the Cenozoic rocks and the lack of detailed studies over the whole of the area preclude precise correlations between their areas of outcrop at this time.

TERTIARY ROCKS

The Tertiary rocks in south-central Yavapai County are composed of

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1/ Museum of Northern Arizona, Flagstaff.

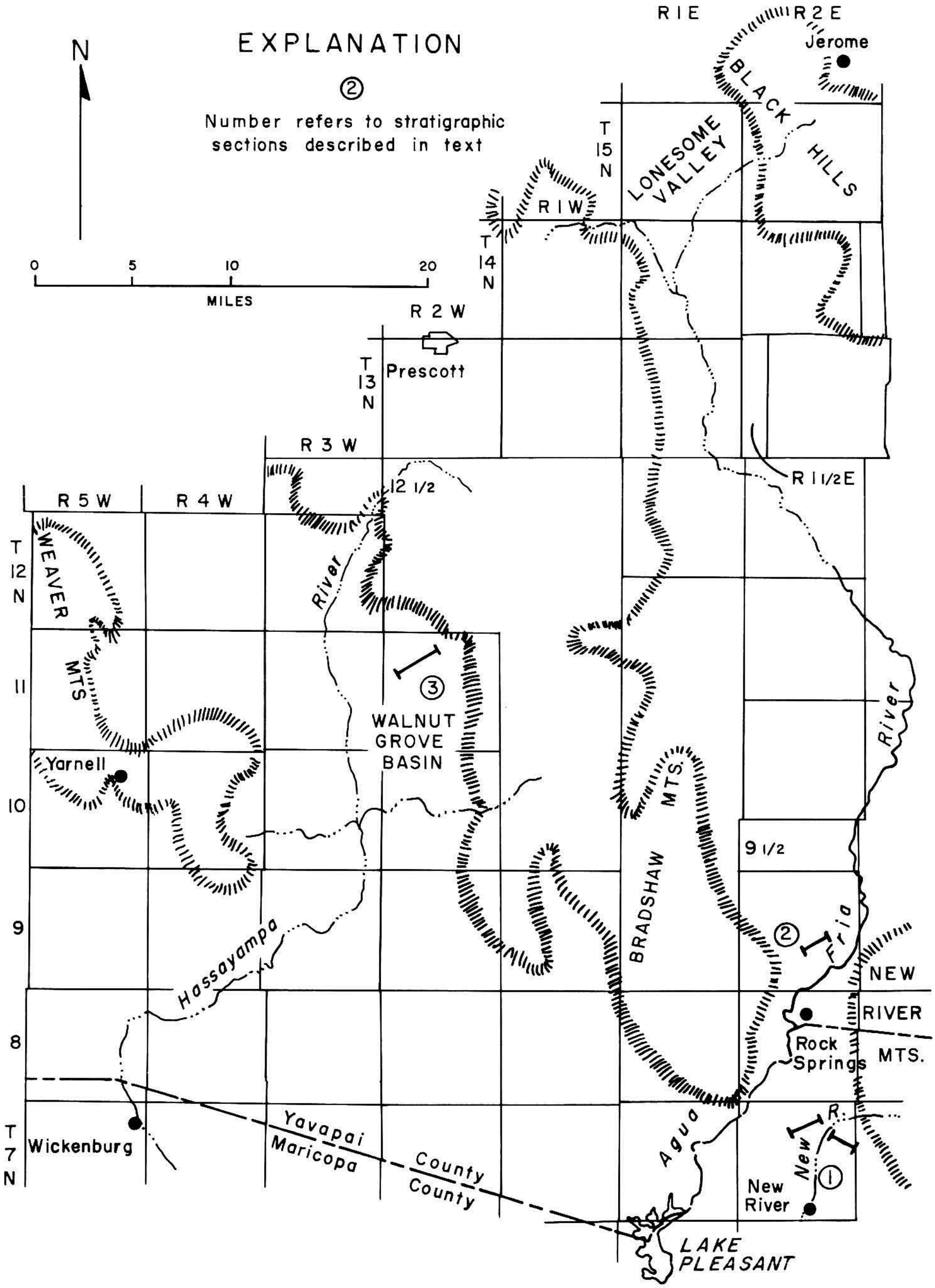

Figure 5. 1. --Part of southern Yavapai County, Ariz., showing selected topographic features and general locations of measured sections.

volcanic and terrestrial sedimentary deposits of probable middle Tertiary and Pliocene age. The deposits were laid down in basins developed by deformation involving Precambrian crystalline rocks. The Tertiary deposits have been extensively eroded but their original thickness locally may have been in excess of a few thousand feet.

Geologic work on the Tertiary deposits has been limited to a general description of the rocks in the Bradshaw Mountains quadrangle (Jaggar and Palache, 1905) and the more recent detailed examinations of the later Tertiary basin-filling deposits in the Walnut Grove basin (Hook, 1956; Plafker, 1956) and in the vicinity of Rock Springs (St. Clair, 1957).

Rock Springs Beds

The Tertiary sedimentary and volcanic deposits that partially fill the valley between the Bradshaw and New River Mountains are herein designated as the Rock Springs Beds for their exposures north and south of the community of Rock Springs. The essentially horizontal Rock Springs Beds underlie a dissected plain and are well exposed along many steep mesa slopes.

The Rock Springs Beds are composed principally of volcanic flow rocks, tuffaceous sandstone, clastic sandstone, and conglomerate. The most common volcanic flow rocks are composed of olivine basalt, hornblende basalt, or hornblende andesite. The tuffaceous sandstone is made up essentially of fine-grained pumice with minor amounts of rounded to subangular sand grains of quartz, feldspar, dark minerals, and some mica. The tuffaceous sandstone is poorly sorted, deeply weathered, and poorly cemented. The clastic sandstone is characterized by the fine-grained size of its particles, which are rounded to subrounded, fairly well sorted, and moderately to weakly cemented, commonly with lime. The particles are composed principally of quartz, feldspar, mica, and several dark minerals. Lenses of boulder conglomerate occur locally in the sequence and are poorly sorted and show indistinct bedding. They are composed either of only volcanic or of only Precambrian rock fragments. Individual beds range in thickness from a few inches to a few tens of feet.

Two partial sections of the Rock Springs Beds, about 9-1/2 miles apart, are described below. The base of the lower part of the Rock Springs Beds measured (section 2) is buried by Quaternary alluvium along the New River and the base of the upper part of these beds (section 1) rests on the erosion surface cut on the Precambrian rocks. This apparent anomaly, shown diagrammatically in figure 5.2, is due to the progressive overlap of the Tertiary deposits upon the underlying erosion surface as the basin was filled. The thickness of Rock Springs Beds unaccounted for due to the lateral discontinuity of the measured sections is not known, but it is believed not to exceed more than a few hundred feet.

Section 1. Partial section of Tertiary(?) Rock Springs Beds measured in secs. 22 and 27, T. 9 S., R. 2 E., Yavapai County, Arizona (after St. Clair, 1957). Beds dip about 4°S.

	Thickness (in feet)
Erosion surface.	
Rock Springs Beds:	
19. Olivine basalt flows: 3 flows, each about 10 feet thick	29

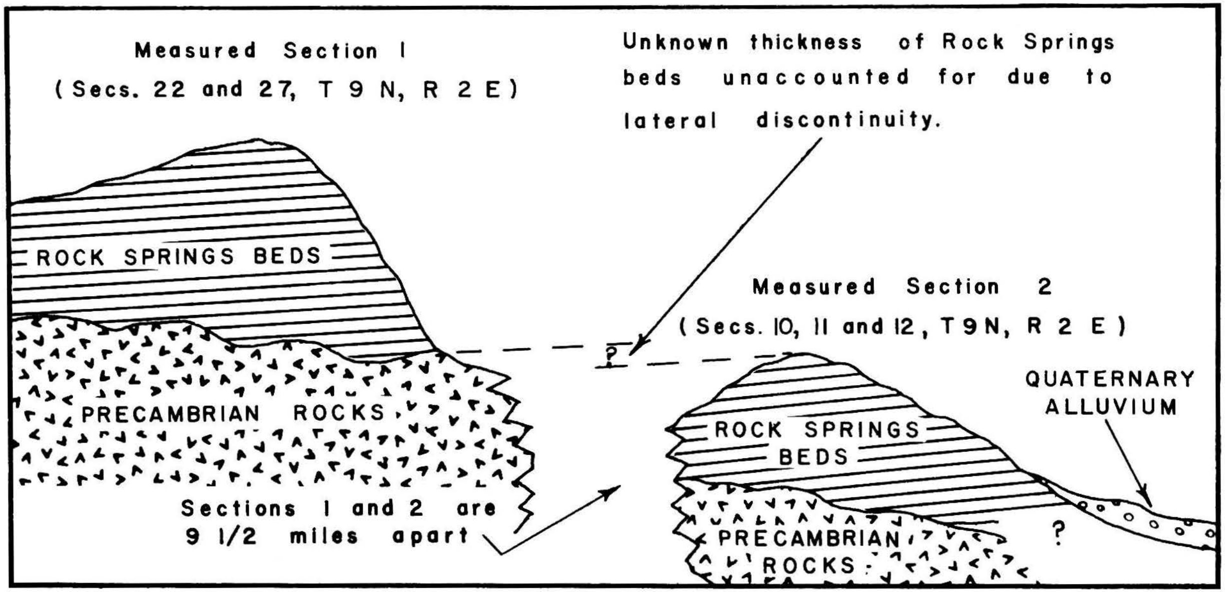

Figure 5. 2. --Diagrammatic sketch showing relationships of measured sections of the Rock Springs beds, Yavapai County, Ariz.

		Thickness (in feet)
18.	Sandstone: light brown; predominantly coarse quartz; contains local lenses of light-brown siltstone	25
17.	Andesite flow	11
16.	Basalt flow	17
15.	Andesite flow: highly weathered	3
14.	Sandstone: tan to buff; mainly quartz grains; poor calcareous cement; locally light-gray siltstone and lenses of volcanic pebbles	36
13.	Hornblende andesite flow (or flows)	45
12.	Hornblende olivine basalt flows: between some of the flows a flow breccia has been developed	102
11.	Andesite flow: vesicular; contains calcite amygdules	12
10.	Olivine basalt flow: contains some hornblende phenocrysts; basal 5 feet is flow breccia	45
9.	Conglomeratic sandstone: reddish tan; coarse sand-size fragments; pebbles are volcanic rock fragments; weak calcareous cement; weathers to a small cliff	37
8.	Olivine basalt flows: base of each of the 3 flows shows a chilled border; basal flow contains hornblende and olivine	38
7.	Conglomeratic sandstone: light brown; coarse sand-size particles; pebbles composed wholly of Precambrian fragments (gneiss, schist); forms very steep slope; weak calcareous cement	151
6.	Sandy siltstone: light tan; poorly sorted	20
5.	Olivine basalt flow: vesicular; base is flow breccia	15
4.	Mudstone: reddish brown; only locally developed	5
3.	Hornblende andesite flow breccia: reddish purple	20
2.	Tuffaceous sandstone: composed of individual beds 3 to 4 feet thick distinguished by slight color and textural variations; locally contains volcanic rock pebbles	75
1.	Sandstone: red brown to tan; coarse; basal conglomerate composed of Precambrian rock fragments	23
	Total Rock Springs Beds measured	709

Unconformity.

Precambrian crystalline rocks.

Section 2. Partial section of Tertiary(?) Rock Springs Beds measured in secs. 10, 11, and 12, T. 7 N., R. 2 E., Yavapai County, Arizona (after St. Clair, 1957). Beds are essentially horizontal.

Erosion surface.	Thickness (in feet)
Rock Springs Beds:	
8. Basalt flow: vesicular; some zeolite amygdules	15
7. Tuffaceous sandstone: light gray to light buff; composed of beds 4 to 5 feet thick distinguishable by slight variations of color and texture	125
6. Sandstone: white; strong calcareous cement; shows crossbedding	20
5. Conglomeratic sandstone: light tan to brown; few interbedded sandstone beds 1 to 5 feet thick; local lenses of sandstone and siltstone	72
4. Sandstone: light brown to grayish tan; local lenses of pebbles; base is tuffaceous	60
3. Hornblende andesite flow: few phenocrysts of olivine; basal 15 feet flow breccia	45
2. Agglomerate: reddish orange; andesite composition; fragments lapilli size	12
1. Hornblende andesite flow: vesicular	75
Total Rock Springs Beds measured	424

Covered by Quaternary alluvium along the New River.

Individual beds lens out or change in character laterally. The areal extent of individual flows and groups of beds of similar lithology usually is limited to a few square miles. Vertically, the Rock Springs Beds range from predominantly tuffaceous sediments in the lower part of the section to predominantly volcanic flows in the upper part of the section. The volcanic rocks in the section are predominantly flows, and the sedimentary rocks are predominantly lacustrine deposits of material of volcanic origin. The conglomerates within the section appear to be locally derived lenses of fluviatile origin. The variation in the stratigraphy from place to place may be due to the volcanic rocks having been erupted from several sources and the clastic rocks having been derived locally.

The Rock Springs Beds rest upon an irregular erosion surface with up to about 100 feet of local relief cut on Precambrian rocks. High-angle faults in the Precambrian rocks suggest that faulting may have increased the original relief. The Rock Springs Beds have been extensively eroded and are the remnant of Tertiary materials which may have been up to about 2,000 feet thick.

No fossils are known from the Rock Springs Beds. These deposits are in part lithologically similar to the Milk Creek Beds of known Pliocene age, described below. The two units may represent generally contemporaneous deposition in two separate basins.

Milk Creek Beds

The Milk Creek Beds (Reed, 1950; Bryant, 1951; Hook, 1956; Plafker, 1956) are located in the Walnut Grove basin, about 29 miles northwest of Rock Springs in whose vicinity the Rock Springs beds are exposed. The two areas are separated by the Bradshaw Mountains which rise some 3,000 feet above each area. The Milk Creek Beds consist of about 2,500 feet of fluviatile and lacustrine sediments, which are interbedded with several layers of tuff and a thick basalt flow.

According to Hook (1956) the Milk Creek Beds are lacustrine sediments composed predominantly of siltstone and fine-grained sandstone, with deposits of a coarse conglomerate which border the Walnut Grove basin. Three members are recognized, based partly on lithology and partly on structure. The lowest unit is composed chiefly of conglomerate and conglomeratic sandstone and is about 500 feet thick; the middle unit is for the most part composed of siltstone and sandstone with interbedded tuff and is about 1,000 feet thick; and the uppermost unit is composed predominantly of siltstone and sandstone with interbedded tuff and is about 700 feet thick. The uppermost unit differs from the middle unit chiefly by being locally crossbedded. The lowest and middle units are separated by a basalt flow that is about 350 feet thick. A composite section of these beds, based on the work of Hook (1956), is given below.

Section 3. Composite section of Tertiary Milk Creek Beds (after Hook, 1956).

Erosion surface.

Conglomerate: light tan to gray; silt to granule matrix; poorly sorted, subangular to subrounded fragments up to 2 feet in diameter, but predominantly pebble sized; fragments tend to become coarser upward, grading locally into fanglomerate; well cemented; weathers to rounded cliffs and ledges.

Unconformity.

Milk Creek Beds:

	Thickness (in feet)
Upper unit; measured in the W-1/2 sec. 5, NE-1/4NE-1/4 sec. 7, and NW-1/4NW-1/4 sec. 8, T. 11 N., R. 2 W. Beds dip gently about 10° NE:	
14. Conglomeratic sandstone: light tan; granule lenses with local pebbles and small cobbles; resistant	23
13. Crossbedded sandstone: light gray; bedding 4 to 7 feet thick; medium grained	18

		Thickness (in feet)
12.	Sandstone: light tan; with local conglomeratic lenses and layers; local graded bedding; resistant	27
11.	Crossbedded sandstone: light gray; bedding 5 to 10 feet thick; fine to medium grained with silt	45
10.	Conglomerate and sandstone: light tan; thinly bedded; locally crossbedded at base	27
9.	Crossbedded sandstone: light gray; medium- to coarse-grained sand and some silt; conglomerate lenses and graded bedding in foresets; bedding 5 to 12 feet thick; calcareous	69
8.	Sandstone and siltstone: light tan; sandstone medium to coarse grained; friable; nonresistant	36
7.	Crossbedded sandstone: light gray; fine- to coarse-grained sand with silt and granules; bedding 6 to 12 feet thick; highly calcareous	51
6.	Sandstone: light gray; fine to coarse grained; bedding 6 inches to 2 feet thick; locally crossbedded; fossiliferous; 3-foot bed of well-cemented sandstone at base	21
5.	Crossbedded sandstone: light gray; medium to coarse grained, with some silt and granules; bedding 3 to 12 feet thick; calcareous; fossiliferous near base; 1-foot bed of siliceous sandstone 48 feet above base	72
4.	Sandstone: light gray green; medium grained with some clay, silt, and granules; bedding 4 to 5 feet thick; fossiliferous near base	12
3.	Crossbedded sandstone: light gray to tan; fine to coarse grained, with some silt and local layers of granules; graded bedding in foresets; bedding 8 to 10 feet thick in upper 40 feet; laminated in lower portion; two 2-foot light-gray resistant sandstone beds at base and 21 feet above base	63
2.	Siltstone and sandstone: light gray green to light tan; interbedded with beds from 6 inches to 5 feet thick; sandstone generally thin bedded, resistant	58

	Thickness (in feet)
1. Covered zone: interbedded siltstone and massive sandstone; sandstone is light gray; siltstone is light tan or gray green; locally tuffaceous; basal sandstone layers are hard; compact, becoming more friable upward	225
Total upper unit measured	747

Conformity.

Middle unit; measured in W-1/2W-1/2 sec. 16, and SE-1/4SE-1/4 sec. 17, T. 11 N., R. 2 W. Beds dip about 15° NE:

19. Tuff: light yellow green; glassy; lower part massive and blocky; upper part fissile and platy; resistant to somewhat friable	5
18. Siltstone: light tan to light gray; with local layers of green to reddish-tan mudstone and thin brown sandstone; crossbedded near base; fissile tuff near base; bedding from 2 to 12 feet thick; slightly calcareous, weathers to badlands	178
17. Tuff: white to light cream; fine grained; somewhat glassy; massive; brittle; weathers blocky	5
16. Sandstone and siltstone: light tan to gray; interbedded with thin white tuff and dark-brown resistant sandstone; weathers to badlands	62
15. Tuff: white; hard; brittle; locally fissile and glassy; contains biotite	4
14. Siltstone and silty clay: light tan, locally light gray green; siltstone contains clay and is in beds 1 to 6 feet thick; interbedded with 2- to 6-inch thick layers of brown resistant sandstone; contains layers of rounded volcanic bombs up to 10 inches in diameter; locally slightly calcareous; weathers to badlands	215
13. Tuff: white	3
12. Siltstone and sandstone: interbedded	4
11. Tuff: white; with biotite flakes; weathers blocky	1.5
10. Silty clay: light tan; interbedded with 1 foot layers of resistant gray sandstone; volcanic bombs locally; bedding 2 to 12 feet thick; calcareous; weathers to badlands	98

	Thickness (in feet)
9. Tuff: white, well cemented; slightly calcareous; blocky	2.5
8. Sandy siltstone: light tan to gray, locally gray green; locally contains clay and interbedded 1 inch to 1 foot layers of sandstone; 1 foot silty tuff at base; weathers to badlands	82
7. Mudstone: light tan to gray with local layers of gray green; some interbedded 1 inch to 2-foot layers of sandstone; bedding 10 to 15 feet thick; weathers to badlands	192
6. Tuffaceous siltstone: light gray to gray green; with interbedded green clay and white tuff 2 feet thick; massive; nonresistant	46
5. Tuff: white	4
4. Siltstone and mudstone: light gray to greenish gray; bedding 2 to 6 inches thick; nonresistant	40
3. Tuffaceous siltstone: light gray; compact; well sorted; friable; siliceous; silicified white tuff 18 inches thick at top	16
2. Siltstone: light tan; well sorted; bedding 12 to 18 inches thick; siliceous; moderately resistant	77
1. Conglomerate: light tan; bedding 6 to 12 inches thick; well cemented; contains pebbles and cobbles of basalt and dacite up to 6 inches in diameter; matrix well sorted; local sandstone and siltstone layers; 1 foot tuffaceous conglomerate at base	27
Total middle unit	1,062

Conformity.

Basalt: dark gray to greenish black; contains phenocrysts of augite; locally vesicular; locally jointed; flow structure near base.

Basalt; measured in NE-1/4SW-1/4 sec. 17, T. 11 N., R. 2 W.:

Basalt: dark gray to greenish black; contains phenocrysts of augite; locally vesicular; locally jointed; flow structure near base	342

Conformity.

Lower unit; measured in the SE-1/4SW-1/4 sec. 17, and NE-1/4NW-1/4 sec. 20, T. 11 N., R. 2 W. Beds dip about 30^{o} NE:

	Thickness (in feet)
12. Siltstone and mudstone: light tan, with upper 3 to 4 feet brick red; bedding 1/2 to 1 inch thick; 2-foot white tuff bed 40 feet above base; 2-foot white silty tuff at base	53
11. Conglomerate: light tan to gray; predominantly pebbles with some cobbles, becoming a conglomeratic sandstone toward the top; some interbedded layers of sandstone and siltstone; massive; well cemented; resistant	21
10. Tuffaceous siltstone and sandstone: light gray; fine grained; bedding 4 inches to 3 feet thick; local layers of mudstone 2 inches thick	25
9. Sandy siltstone: light tan; massive; compact	12
8. Tuffaceous silty sandstone: light gray; fine-grained sand; massive; compact; friable	65
7. Tuffaceous silty sandstone: light gray to gray green; conglomeratic near top with granules and some pebbles; poorly sorted; massive; compact; resistant	154
6. Tuffaceous silty sandstone: light gray; medium-grained sand with silt and tuff particles; conglomeratic sandy siltstone near base; interbedded layers of tuffaceous mudstone 1 foot thick	29
5. Conglomerate: light gray; subangular to subrounded; poorly sorted; pebbles and cobbles of gneiss and granite; matrix contains silt and sand; massive; resistant	7
4. Conglomeratic sandstone: light gray; silty toward top, tuffaceous; slightly calcareous	30
3. Conglomeratic sandstone: light tan to yellow tan, gray green at top; coarse sand matrix with pebbles and granules; massive; compact; resistant	32
2. Conglomerate: light tan to gray; cobbles; subangular to subrounded; poorly sorted; composed of granite, gneiss, phyllite, and schist; resistant	8

	Thickness (in feet)
1. Conglomeratic sandstone: light tan to yellow brown; coarse sandstone with pebbles and cobbles; poorly sorted; compact; massive; resistant	60
Total lower unit	496
Total Milk Creek Beds (not including basalt) ..	2,305

Erosional unconformity.

Dacite:	50±

Erosional unconformity.

Granite.

The Milk Creek Beds were deposited on an erosion surface cut either on Precambrian crystalline rocks or on a dacite flow of presumed Tertiary age. The beds have been tilted to the north or northeast with dips commonly ranging from about 10^{o} to 25^{o} and are locally faulted.

The upper 300 to 400 feet of the Milk Creek Beds has been dated as lower Pliocene (Clarendonian) on the basis of a vertebrate fossil assemblage. The nearly 2,000 feet of sediments underlying the fossiliferous horizon is also assumed to be lower Pliocene, although it is possible the sediments may in part span the Miocene-Pliocene boundary.

QUATERNARY ROCKS

Throughout south-central Yavapai County there are dissected terrace, flood-plain, and alluvial fan deposits, which are composed predominantly of gravel and fine sand but which locally contain predominantly finer grained materials. These lie with an erosional or angular unconformity on the older rocks and are in many places themselves separated from each other by erosional hiatuses. In the Walnut Grove basin, finer grained deposits overlying probable equivalents of the Milk Creek Beds contain a Pleistocene vertebrate fauna (Hook, 1956). These finer grained materials are in turn conformably overlain by terrace gravels, which are interpreted as being of probable Pleistocene age (Hook, 1956). Some of the stream channel deposits are of Recent age. These deposits are being dissected at the present time.

STRUCTURE

Although south-central Yavapai County lies in the mountain region, which is structurally higher than the adjoining Colorado Plateau and Basin and Range provinces, the Cenozoic rocks are comparatively undeformed, except near the southern boundary of the mountain region. Broad, open folding and small-scale faulting are the most obvious structural features in the southern part of the area, and slight regional northeast tilting is evident in the northern part of the area. The few major Cenozoic structures have northwest to north-northwest trends.

South of Rock, the Cenozoic rocks have been folded into broad, open, west-northwest-trending anticlines and synclines. The folds plunge westward at low angles and are partly buried beneath Quaternary fill. Several northwest- and east-west-trending faults of small magnitude are associated with the folds. The folding and faulting appear to be related to a major zone of east-west faulting along the southern boundary of the mountain region in the vicinity of Cave Creek.

The Pliocene deposits of the Walnut Grove area are tilted about 20^{o} to the northeast, but the Rock Springs beds are flat lying or tilted a few degrees northeast. Some of the dip in the Cenozoic rocks may be due to initial dip.

PROBLEMS OF THE CENOZOIC IN SOUTH-CENTRAL YAVAPAI COUNTY

Several problems concerning the Cenozoic history of south-central Yavapai County have been emphasized and delineated through the recent studies in south-central Yavapai County. Some of these problems are outlined below.

1. What is the history of the development of the pre-volcanic erosion surface? What is its age? What are its relationships to other pre-volcanic erosion surfaces?

2. What are the sources of the volcanic rocks, presumed to be Tertiary? In what form were they deposited? Did they blanket the area, or do they represent large-scale tongues? Southeast and north of the Bradshaw Mountains there are several andesite plugs and a few basaltic dikes. Are these the sources of the tremendous volume of volcanic material that even now, after considerable erosion, covers extensive areas in the region? What are the relationships, if any, of the volcanic rocks in the general vicinity of south-central Yavapai County to the volcanic fields on the Colorado Plateau?

3. The Cenozoic deposits in the mountain region in central Arizona were deposited on an erosion surface that locally had hundreds of feet of relief. This relief was in the form of several distinct but possibly interconnected basins of deposition surrounded by hills. The origin of this relief is not known and may have been caused by erosion along earlier structural trends, by differential movement of fault blocks, by tilting of fault blocks, or by combinations of these.

4. The central part of the mountainous transition zone acted essentially as a single structural unit during Cenozoic time and, as such, contrasts greatly with the Colorado Plateau and Basin and Range provinces. The faults south of the Bradshaw Mountains and in the vicinity of Cave Creek which are shown on the Tectonic Map of the United States may well represent the southern boundary of the mountain region. Here, Tertiary rocks have been faulted relatively downward on the south and, for the most part, covered by Quaternary and Recent sediments. The northern boundary of the mountain region appears to be parallel to and somewhat south of the Mogollon Rim, but the exact structural relations are unknown. The problem is, what are the structural relationships of the boundaries of the mountain region to the Colorado Plateau and the Basin and

Range provinces?

5. Recent evidence (McKee, 1951; Chew, 1952a, and this volume; Brennan, 1957, and this volume) indicates that there was a period of orogeny in southern Arizona following the lower Miocene involving thrusting and local overturning of middle Cenozoic rocks. Relatively undeformed Pliocene and Pleistocene rocks lie on the strongly deformed Miocene and earlier rocks. There is no record in south-central Yavapai County of a period of deformation definitely related to this one.

6. One of basic problems is the lack of datable fossil material from the Cenozoic deposits in this area. The increasing development of the usefulness of pollen analysis may eventually be valuable in establishing the chronology of events in the region.

SUMMARY

South-central Yavapai County is part of a mass of crystalline Precambrian rocks covered, in several places, by thick deposits of Cenozoic volcanic and sedimentary rocks. The rocks are composed of sequences of volcanic flows, conglomerate, sandstone, siltstone, and tuffaceous sandstone. The volcanic rocks are largely the products of eruptions in middle(?) Tertiary time. Dissected Pleistocene and Recent gravels, terrace deposits, and alluvial fans rest with erosional unconformity on the Tertiary rocks throughout the area.

Most of the Tertiary rocks are nearly horizontal; some dip to the northeast 5° to 20°. Structural features are for the most part minor. The few major Cenozoic structures have northwest to north-northwest trends.

The preliminary investigations of the Tertiary rocks of this area serve mainly to emphasize the lack of information regarding a number of the major relationships of the Cenozoic rocks in the area. One of the basic difficulties is the lack of datable fossil remains from the deposits in this area. Fossils of upper Pliocene age occur in a narrow zone in the upper part of the Milk Creek Beds.