Stratigraphy of the Dripping Spring Quartzite Southeastern Arizona

GEOLOGICAL SURVEY BULLETIN 1168

Prepared on behalf of the U.S. Atomic Energy Commission

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UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1964

UNITED STATES DEPARTMENT OF THE INTERIOR

STEWART L. UDALL, *Secretary*

GEOLOGICAL SURVEY

Thomas B. Nolan, *Director*

The U.S. Geological Survey Library catalog card for this publication appears after page 119.

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402

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By H. C. GRANGER and R. B. RAUP

ABSTRACT

The Dripping Spring Quartzite, a feldspar-rich clastic sedimentary rock, is the thickest, most widely exposed, and perhaps the best preserved formation in the upper Precambrian Apache Group in southeastern Arizona. Where fully developed in Gila County, the Dripping Spring ranges in thickness from about 450 to slightly more than 700 feet; it is divided into the Barnes Conglomerate Member, middle member, and upper member. The Barnes Conglomerate Member is most commonly between 5 and 20 feet thick and is composed largely of well-rounded quartzose pebbles and cobbles in a medium- to coarse-grained feldspar-rich matrix. The middle member is typically a medium-grained, feldspar-rich sandstone or orthoquartzite that ranges in thickness from about 140 to nearly 370 feet. The upper member is a thinly stratified sequence of silty to fine-grained feldspar-rich rocks divided into the red, gray, buff, and white units, which may be further subdivided into facies that can be correlated throughout most of Gila County. The upper member ranges in thickness from 180 to 400 feet in Gila County but is generally more than 240 feet thick.

The red unit of the upper member is composed of hematitic and micaceous siltstone and sandstone. The gray unit comprises carbon-bearing siltstones and sandstones that contain as much as 14.6 percent K_2O. The buff unit is largely feldspathic sandstone and the white unit is largely argillaceous siltstone.

Various sedimentary structures as well as regional variations in composition, grain size, and thickness were studied in an attempt to determine the source areas of the clastic material and the shape of the basin of deposition. The shape of the basin of deposition in Gila County, as indicated by isopach maps, appears to be an arm or embayment that extends northeastward from a larger sea to the southwest. Source areas are still in doubt because of conflicting evidence, but much of the material that makes up the Dripping Spring in Gila County seems to have been derived from a southerly source. Some material, however, was derived locally in the northern part of the county, and the possibility of several source areas is recognized.

The history and environments of deposition of the Dripping Spring Quartzite indicate that the lower part of the middle member and the Barnes Conglomerate Member were sorted and redistributed from talus outwash by an encroaching sea. This sea then retreated as the sedimentation rate exceeded subsidence of the basin; the upper part of the middle member was deposited offshore and in the littoral zone while the red, gray, and buff units of the upper member were being deposited on tidal or mud flats of a flood plain bordering the sea. When subsidence in turn exceeded sedimentation, the sea again transgressed the Gila

County area, depositing a white quartzite in the littoral zone and depositing the white unit out from the shore. Preceding deposition of the argillaceous carbonate rocks of the overlying Mescal Limestone, erosion near the margins of the basin removed much of the white unit and provided material for the poorly sorted strata at the base of the Mescal.

INTRODUCTION

The Dripping Spring Quartzite is a feldspar-rich clastic sedimentary rock in the upper Precambrian Apache Group of southeastern Arizona. The Apache Group consists of the Scanlan Conglomerate, the Pioneer Formation, the Dripping Spring Quartzite, the Mescal Limestone, and basalt; of these the Dripping Spring is the thickest, most widely exposed, and perhaps the best preserved unit.

We had an opportunity to study the Dripping Spring during examinations of many uranium deposits within the formation. Particular emphasis was given to stratigraphic study in and near Gila County (fig. 1), the principal area of exposure (pl. 1) during a 3-month period in 1955. Seventeen stratigraphic sections, including complete and incomplete sections, were studied in detail, and additional data were gathered from many isolated exposures. We have freely drawn upon the work of other geologists, both within and outside Gila County, to supplement our information.

Most of the data result from field observations, and from these, isopach maps and descriptive analyses of the measurable properties were prepared. In the laboratory, rock specimens were studied in thin section and by semiquantitative spectrographic and X-ray diffraction spectrometric methods.

The geology of most of the outcrop area of the Dripping Spring had never been mapped in detail; hence, much time was required to find complete, little-faulted, and adequately exposed sections for study. Each section presented is believed to be typical and representative of the formation in the surrounding area, which, in several places, was mapped or thoroughly traversed. In general, local variations that may be present are probably too insignificant to alter the pattern established by the measured sections.

ACKNOWLEDGMENTS

An early draft of this report was reviewed by N. P. Peterson, E. D. Wilson, and A. F. Shride, all of whom have worked in areas containing the Dripping Spring Quartzite. Their comments regarding the descriptive material and conclusions set forth in this paper were gratefully received and carefully considered. The conclusions presented, however, are ours and do not necessarily concur with the opinions currently held by the reviewers.

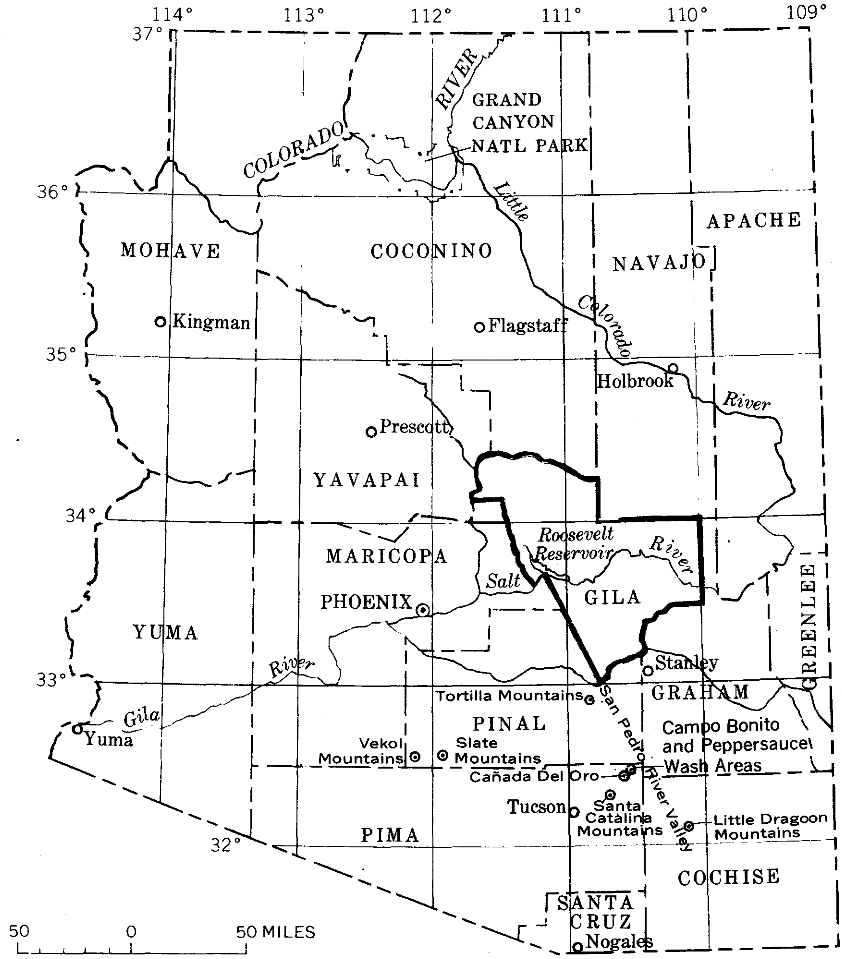

FIGURE 1.—Index map of Arizona, showing Gila County and other localities referred to in text.

We are greatly indebted to F. B. Moore, who assisted in field measurement of most of the stratigraphic sections and aided in preliminary compilation of many of the data.

These investigations of the Dripping Spring Quartzite were done on behalf of the Division of Raw Materials of the U.S. Atomic Energy Commission.

HISTORY AND PREVIOUS WORK

The Apache Group, which includes the Dripping Spring Quartzite, was not named or subdivided until many years after rocks of the group had first been noted and described. As early as 1857, Antisell briefly described rocks in the valleys of the Gila and San Pedro River that were lithologically similar to the Apache Group. Gilbert (1875) also described rocks of the Apache Group, but he carried the work one step further by suggesting that the rocks resembled and therefore probably could be correlated with rocks of the lower part of the Tonto Group in the Grand Canyon region. Marvine (1875) agreed in essence with Gilbert's proposed correlation. Such a correlation implied a Cambrian age for the Apache Group.

In 1903, Ransome formally named and assigned an age to the Apache Group as the result of his studies in the Globe area. He suggested a Cambrian or older age for the group, which at that time included only the Scanlan Conglomerate, Pioneer Shale, Barnes Conglomerate, and Dripping Spring Quartzite, in order of decreasing age. Also in 1903, Reagan, working independently in northeastern Gila County, described rocks which were later recognized as Apache Group but which he referred to as Algonkian in age. Reagan's view regarding the age of the Apache Group was also held by Lee (1905) and later by Darton (1910). Lee suggested that sedimentary rocks he mapped as Precambrian in the Roosevelt Dam area were probably the same rocks as Ransome's Apache Group in the Globe area. Darton (1910) suggested that Reagan's Precambrian sedimentary rocks represented the Algonkian Grand Canyon Series.

In 1915, Ransome redefined the Apache Group to include rocks that he named the Mescal Limestone and the Troy Quartzite. He considered the Troy to be of Cambrian age and the Mescal and underlying rocks to be Cambrian or earlier. Mapping in the Ray area had disclosed that the Mescal Limestone had inadvertently been included with the Globe Limestone of Devonian and Carboniferous age in the Globe area and that the Troy Quartzite had been included in the Dripping Spring. Presumably, the Dripping Spring was originally termed a quartzite because of the dominant lithology of the Troy and not because of any preponderance of quartzite in the Dripping Spring.

In 1916, Ransome revised his stand on the age of the Apache Group and suggested that it was no older than Cambrian and possibly was Ordovician and Silurian in part.

In 1925, Darton classified the Apache Group as Cambrian(?) in the text of his classic "A Resume of Arizona Geology," but in discussing this classification (1925, p. 36) he reasserts his opinion that the Apache Group should be correlated with the Grand Canyon Series and thus should be Algonkian in age. In the same paper, however, Darton reported that his data indicated a long interval between deposition of the Mescal Limestone and the Troy Quartzite and that he had found fossils of Late Cambrian age in strata that conformably overlie the Troy or are included in the upper part of the Troy. These were the first indications that perhaps the Troy should not be included in the Apache Group; Stoyanow (1930) added further evidence when he reported finding Middle Cambrian fossils in the Troy. In 1932, Darton removed the Troy Quartzite from the Apache Group on the grounds that the Troy was Cambrian in age and the Apache Group was Precambrian in age. Also in 1932, Ransome concurred with this judgment.

Our investigations indicate that the Troy is Precambrian in age and that the boundary between Precambrian and Paleozoic rocks is between the Troy and the Bolsa Quartzite or its equivalent. (See footnote, p. 8.) Although this change makes rocks of both the Troy and the Apache Groups Precambrian in age, the evidence of a strong erosional interval between deposition of the two rocks remains as sufficient reason for not returning the Troy to the Apache Group.

Peterson, Gilbert, and Quick (1951) changed the name Pioneer Shale to Pioneer Formation in the Castle Dome area, and we have here defined the Barnes as a member of the Dripping Spring Quartzite. We also have included basalt in the group, so that now the Apache Group as defined consists of Scanlan Conglomerate, Pioneer Formation, Dripping Spring Quartzite, Mescal Limestone, and basalt (fig. 2).

Studies involving the Apache Group in recent years have included graduate theses, particularly from the University of Arizona, as well as work by Wilson (1939), Hinds (1935, 1936), Short and others (1943), Peterson, Gilbert, and Quick (1951), and Gastil (1954). Kaiser (1951), Mead and Wells (1953), Wells and Rambosek (1954), Magleby and Mead (1955), Sharp (1956), and Williams (1957) have published information concerning the uranium deposits in the Dripping Spring.

GENERAL GEOLOGY

The oldest rocks in Gila County are detrital sedimentary, pyroclastic, and volcanic rocks of early Precambrian age; near large bodies of intrusive rock these are metamorphosed to gneiss and schist. In the southern part of the county these rocks are classified as the Pinal Schist; its equivalent, at least in part, the Yavapai Series, has locally been subdivided into groups and formations in the northern part of the county (Wilson, 1922, 1939; Gastil, 1953). Extensive bodies of granite of early Precambrian age intrude all the other lower Pre-

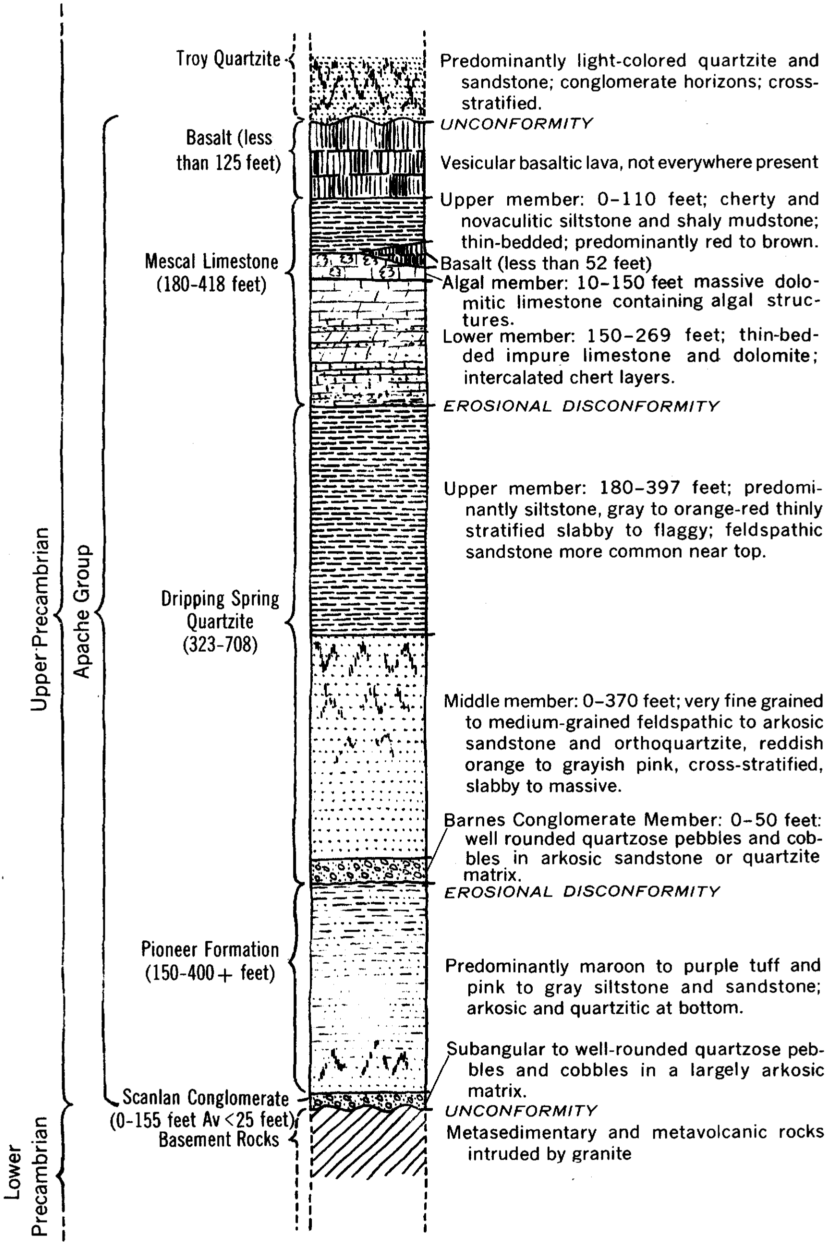

FIGURE 2.—Generalized columnar section of the Apache Group, Gila County, Ariz.

cambrian rocks. Lead-uranium ratios in zircons from granitic rocks of comparable age in the Little Dragoon Mountains (table 1) indicate an age of 1660±20 million years (L. T. Silver, written communication). The potassium-argon and rubidium-strontium ratios of minerals in similar granitic rocks from other parts of southern Arizona suggest ages ranging from 1,160 to 1,500 million years (Aldrich, Wetherill, and Davis, 1957).

Sedimentary rocks of the Apache Group of late Precambrian age lie on an irregular surface cut in the granite and older rocks. The Scanlan occupies the position of basal conglomerate beneath the Pioneer Formation which is composed entirely of indurated detrital material ranging from silt and feldspathic sand to pyroclastic fragments. The Barnes Conglomerate Member of the Dripping Spring was deposited on a nearly conformable erosion surface on the Pioneer Formation, suggesting epeirogeny that produced a pronounced change of conditions in the basin of deposition or in the source area without attendant deformation of the floor of the basin. In general, the Dripping Spring becomes finer grained and more evenly and thinly stratified upward, suggesting a gradual return to eustatic conditions.

TABLE 1.—*Ages of older Precambrian granitic rocks in Arizona*

Locality	Rock	Mineral	Method of determination	Age (10^6 years)	Reference
Wickenburg	Pegmatite	Mica	K-A	1160	Aldrich, Wetherill, and Davis (1957).
	do	do	Rb-Sr	1300	Do.
Grand Canyon	Gneiss	do	K-A	1390	Do.
	do	do	Rb-Sr	1370	Do.
Bagdad	Lawler Peak Granite	do	K-A	1410	Do.
	do	do	Rb-Sr	1390	Do.
	Pegmatite in Lawler Peak Granite.	do	K-A	1410	Do.
	do	do	Rb-Sr	1500	Do.
	Lawler Peak(?) Granite.	Zircon	Pb^{207}/Pb^{206}	1210	Kulp and Eckelman (1957).
Little Dragoon Mountains.	Johnny Lyon Granodiorite.	do	do	1660±20	L. T. Silver, written communication.

Poorly sorted sandstone and siltstone at the base of the Mescal Limestone overlie the Dripping Spring on a disconformable erosion surface. The Mescal marks the end of the sedimentary cycle of the Apache Group, but the depositional history was climaxed by an outpouring of basaltic lavas that disconformably overlie the sedimentary rocks and may have covered the entire region. A possible forerunner of these lava flows is a thin basaltic layer present at the base of the upper member of the Mescal.

The basalt has been considered by most workers to mark the end of the Precambrian record in Gila County, and the Troy Quartzite, which unconformably overlies the earlier rocks, was commonly regarded as the first Paleozoic rock. Lochman-Balk (1956) pointed out that the Troy, however, might well consist of a lower part of Precambrian age and an upper part of Cambrian age. This was borne out by our work on the uranium deposits, which indicated that diabase that was nearly contemporaneous with Precambrian uranium deposits intruded rocks designated as Troy (Granger and Raup, 1959; Neuerburg and Granger, 1960). Age determinations of the uranium deposits by various methods indicate a maximum age between 1,100 and 1,200 million years and a minimum age of 600 million years. A Precambrian age for the Troy was also borne out by structural and stratigraphic relations in northern Gila County (A. F. Shride, oral communication, 1959). Rocks overlying the Troy Quartzite and lithologically similar to the Troy were deposited in some places on truncated diabase. Locally, these younger rocks, which were previously included in the Troy, contain Middle and Late Cambrian fossils suggesting that they are correlatives of the Bolsa Quartzite and Abrigo Limestone of Middle and Late Cambrian age.[1]

The Paleozoic strata overlying the Cambrian rocks range in age from Late Devonian to Permian and are composed predominantly of limestones. The only Mesozoic sedimentary rocks preserved in Gila County are sparse exposures of Cretaceous clastic and pyroclastic rocks in the southern part of the county. Tertiary and Quaternary strata consist of partially consolidated gravels and sands. The most abundant of these are gravels that fill the intermontane basins and form a thin veneer on pediments; they are called Gila Conglomerate on the basis of similarities to the Gila Conglomerate described and named by Gilbert (1875, p. 540–541).

At least twice in the geologic history of Gila County there were intrusions of diabase magmas. Most of the diabase is late Precambrian in age and it intruded extensively the Apache Group and Troy Quartzite. In general, bodies of this diabase are sill like, but discordant contacts are common. Later diabase has been reported by Ransome (1916, 1919), Darton (1925, p. 254), and Peterson, Gilbert, and Quick (1951) in the south-central part of the county, where diabase dikes cut limestones of Pennsylvanian age.

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[1] Subsequent to the preparation of this report the Troy Quartzite has been redefined to consist of rocks of Precambrian age. Rocks of Cambrian age formerly assigned to the Troy are now assigned to the Bolsa Quartzite and Abrigo Formation (Krieger, 1961).

Cretaceous and Tertiary igneous rocks are found principally in the southern part of Gila County. The intrusive rocks consist of quartz monzonite, granite porphyry, diorite, and granodiorite. Extrusive flows and pyroclastic rocks of Cenozoic age are particularly abundant; dacite, andesite, and basalt are the common rock types present.

North of a line that approximately follows the Salt River and Tonto Creek the sedimentary rocks in Gila County are mostly flat lying or dip regionally northward at low angles. Only locally have steeper dips been produced by faulting, monoclinal folding, and irregular inflation by diabase. South of the line the structure is more nearly of the Basin and Range type, and the result is tilted parallel and subparallel block-faulted mountain ranges that are separated by broad, gravel-filled intermontane basins.

ROCKS OF APACHE GROUP OTHER THAN DRIPPING SPRING QUARTZITE

With the exception of the Dripping Spring Quartzite, rocks of the Apache Group have received only cursory examination by us. Brief descriptions of these rocks are included, however, in order to relate the Dripping Spring to the other constituent formations. Underlying the Dripping Spring are the Pioneer Formation and the Scanlan Conglomerate; overlying the Dripping Spring are the Mescal Limestone and basalt (fig. 2).

SCANLAN CONGLOMERATE

The Scanlan Conglomerate, the oldest rock of the Apache Group, is composed predominantly of well-rounded to subangular cobbles and boulders derived from older quartzites in an arkosic and (or) purple shale matrix; vein quartz, red jasper, and schist stones are not uncommon. Stones (p. 75) range from one-fourth of an inch to somewhat more than 10 inches in diameter. Where the Scanlan overlies granite, the composition of the matrix commonly is very similar to that of the decomposed granite.

The Scanlan is not present everywhere, but ordinarily it is represented by at least a thin layer of pebbles. The thickness of the Scanlan is as much as 155 feet (Gastil, 1953), but most commonly ranges from 2 to 15 feet. Generally the Scanlan is on an irregular surface of decomposed older granite, quartzite, or schist of Precambrian age, and most commonly it grades upward into the Pioneer Formation. Where the Scanlan is absent, highly arkosic strata of the Pioneer Formation overlie the older rocks.

PIONEER FORMATION

The Pioneer Formation is a complex section of arkose, quartzite, sandstone, siltstone, and reddish-brown tuffaceous rocks (Gastil, 1953). Most prevalent are arkosic sandstone strata, commonly at the base of the formation, and arenaceous shale and siltstone strata. In a very general way, the grain size and feldspar content decrease upward. Elliptical spots of various sizes bleached to buff, pale green, or pale red are typical of the tuffaceous and siltstone strata.

The thickness of the Pioneer Formation in most of Gila County ranges from 150 feet to more than 400 feet. There are, however, areas in the county in which the Pioneer thins out and disappears by overlap. Darton (1925) noted one such area along the Gila River southeast of Globe. Similar conditions were seen by us and by Gastil (1953) in the northern part of the county.

MESCAL LIMESTONE

The Mescal is divisible into three members: the lower or carbonate member, the middle or algal member, and the upper or siltstone member (Stewart, 1955; Bromfield and Shride, 1956, p. 622).

The base of the lower member marks a well-defined change in lithology from that of the underlying Dripping Spring. In contrast with the well-sorted rocks in the upper member of the Dripping Spring, the basal strata of the Mescal are poorly sorted and consist of medium-grained to granule-sized quartz grains in an argillaceous, locally dolomitic matrix (A. F. Shride, oral communication) (fig. 10). These strata are a few to several tens of feet thick and commonly contain angular to subrounded fragments of the Dripping Spring in the lower few inches, and chert, limestone, and dolomite fragments of the Mescal a few feet above the base.

Above these basal strata the lower member contains heterogeneous sequences of carbonate-rich beds. It consists mostly of thin- to thick-bedded, moderately pure to impure dolomite and limestone intercalated with calcareous shale.

The lower member ordinarily is between 150 and 200 feet thick in Gila County, although as much as 269 feet has been measured by A. F. Shride (written communication) in the Sierra Ancha. Metamorphosed cherty dolomite or limestone strata in the lower member are the principal host rocks for asbestos deposits in Gila County.

The middle or algal member is predominantly a massive dolomite or limestone that commonly contains structural features attributed to the growth of algal colonies during deposition. This member ranges in thickness from 10 feet (Bromfield and Shride, 1956, p. 622) to 150 feet (Stewart, 1955) where measured, but it is absent in some places.

The upper member is composed largely of chert and feldspar-rich siltstones and shales and, locally, thin limestone strata. The thickest known section is in the northern part of Gila County, where 110 feet was measured by Bromfield and Shride, 1956 (p. 623); but this member either was not deposited or was removed by pre-Troy erosion throughout most or all of the southern part of the county.

The maximum thickness of the Mescal in the Sierra Ancha is as much as 418 feet (A. F. Shride, written communication, 1957), but the average thickness is probably nearer 250 feet. The formation thins by overlap and erosion to the north and east.

BASALT

The Mescal Limestone is commonly capped by one or more basalt flows, which total as much as 200 feet in thickness (R. H. Carpenter, 1948) but ordinarily do not exceed 125 feet in Gila County. The basalt is here included as a rock unit because it is nearly conformable with and is intimately associated with the Mescal Limestone. Pre-Troy erosion locally removed some or all of the basalt in Gila County and allowed Troy to be deposited directly on the Mescal and earlier rocks.

In northern Gila County, basalt caps the upper member of the Mescal. Locally, there is also a basalt layer (Granger and Raup, 1959, p. 427) as much as 52 feet thick (A. F. Shride, written communication) between the middle and upper members of the Mescal. The relation of this layer to the enclosing rocks has been obscured by weathering, and whether it is intrusive or extrusive has not been determined.

To the south, where the upper member has not been recognized and may be missing, only one basalt layer is found. This layer caps the lower or middle member of the Mescal and, at least locally, consists of more than one flow (Carpenter, 1948). It is possible that the basalt layers may join to form one layer where the upper member of the Mescal is missing.

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TABLE 2.—*Characteristics of units and subunits of the upper member, Dripping Spring Quartzite, Gila County, Ariz.*

Characteristic	Red unit	Gray unit		Barren quartzite	Black facies	Buff unit exclusive of the white quartzite	White quartzite marker	White unit
		Gray facies	Gray sandstone exclusive of the barren quartzite					
Rock type	Arkosic to feldspathic siltstone and silty sandstone, micaceous.	Arkosic siltstone, local sandstone strata.	Fine-grained feldspathic sandstone and orthoquartzite.	Medium- and coarse-grained feldspathic orthoquartzite.	Arkosic siltstone, local very fine grained sandstone strata.	Feldspathic to arkosic sandstone and intercalated feldspathic orthoquartzite.	Orthoquartzite and sandstone, locally feldspathic.	Arkosic to feldspathic siltstone.
Thickness ... feet	0–83; average about 40.	10–127; average about 65.	5–61; largely 20–30.	0–8; commonly 2	13–120; commonly about 100 in central Gila County.	41–168; average about 95.	0–14	0–124; largely <20.
Grain size	Silt to very fine grained.	Silt to very fine grained; largely silt.	Silt to medium grained; largely very fine to fine grained.	Fine to coarse grained; largely medium grained.	Clay to very fine grained; largely silt; graded strata.	Very fine to fine grained; intercalated fine to medium grained.	Fine to coarse grained.	Clay to fine grained; largely silt; graded strata.
Stratification	Thin bedded to thinly laminated; largely laminated; locally cross laminated.	Thinly laminated to very thin bedded; largely laminated; wispy cross laminae.	Laminated to thick bedded; largely laminated to very thin bedded; cross laminated.	Thin bedded; cross stratified(?).	Very thin bedded to very thinly laminated; largely laminated to thinly laminated; wispy cross laminae.	Thinly laminated to thick bedded; largely very thin bedded; abundantly cross stratified.	Laminated and cross laminated; locally thin bedded.	Thinly laminated to very thin bedded; largely laminated; very locally cross laminated.
Splitting property	Papery to massive; largely flaggy and slabby.	Papery to blocky; largely flaggy.	Flaggy to blocky; largely slabby.	Blocky to slabby; largely slabby.	Papery to blocky; largely flaggy and platy.	Flaggy to massive; largely blocky.	Slabby to blocky	Flaggy to blocky; largely flaggy and slabby
Induration	Moderate to well, except poor in micaceous parts.	Well	Well to quartzitic.	Quartzitic to well.	Well	Well, some quartzitic and novaculitic.	Well to quartzitic.	Well to novaculitic.

Composition (major constituents).	Feldspar—potassic, obscure twinning. Quartz.	Feldspar—largely potassic; some has microcline grid twinning. Quartz—15–30 percent.	Quartz. Feldspar.	Quartz—>90 percent.	Feldspar—largely potassic orthoclase, and adularia (?); some plagioclase and microcline—50–85 percent. Quartz—10–40 percent.	Quartz—55 to 95 percent. Feldspar—microcline, orthoclase, plagiclase—5–40 percent.	Quartz. Feldspar.	Quartz—10 to 90 percent(?). Feldspar—(microcline largely)—10–85 percent(?). Clay minerals—locally abundant.
Composition (minor constituents. Secondary minerals in italics).	Detrital muscovite *Illite* *Jarosite* *Calcite* *Hematite* Magnetite Ilmenite *Leucoxene*	*Clay minerals* Muscovite Carbon Zircon (rare) *Calcite* (rare to none) *Pyrite*	*Clay minerals* *Sericite* Zircon (rare) Carbon (?rare) *Pyrite* *Hematite* Ilmenite	Feldspar *Clay minerals* Zircon (?rare) *Sericite* *Calcite*(?) *Pyrite* *Hematite* Ilmenite	Clay—5 to 20 percent; *montmorillonite-nontronite, illite, allophane*(?) Muscovite (<1 percent) Zircon Carbon (commonly <1 percent; as much as 3 percent) Ilmenite—*leucoxene* *Pyrite* (disseminated) *Limonite—jarosite* *Calcite* (rare)	*Clay minerals* *Sericite*(?) Zircon (rare) Carbon(?) Magnetite Ilmenite *Leucoxene* (rare) *Chert* *Calcite*(?) *Pyrite* (little or none) *Limonite* *Hematite*	*Clay minerals* *Pyrite*(?) (rare) *Hematite* *Limonite*	Plagioclase Muscovite, *sericite*(?) Zircon Carbon (rare) Magnetite Ilmenite *Leucoxene* (rare) Chert *Calcite*(?) *Pyrite* Limonite Hematite
Cement	Fine-grained aggregate of jarosite and hematite; fine-grained calcite.	Authigenic potassic feldspar and quartz, clay and iron minerals.	Silica, clay minerals, rarely authigenic feldspar.	Largely silica	Authigenic potassic feldspar and quartz, clay and iron minerals.	Silica, clay and iron minerals authigenic feldspar and quartz.	Largely silica	Silica, clay, and iron minerals.
Color (freshly broken surface).	Light gray, pale red, pale reddish brown.	Light gray to medium gray.	Pale red to olive gray; largely pale yellowish brown.	Light gray to very light gray.	Dark gray to very light gray.	Very light to yellowish, medium brownish gray, and light brownish gray.	Pinkish, olive, brownish gray to white.	Dark gray to very light gray and grayish orange pink.

TABLE 2.—*Characteristics of units and subunits of the upper member, Dripping Spring Quartzite, Gila County, Ariz.*—Continued

Characteristic	Red unit	Gray unit		Barren quartzite	Black facies	Buff unit exclusive of the white quartzite	White quartzite marker	White unit
		Gray facies	Gray sandstone exclusive of the barren quartzite					
Color (weathered surface).	Very dusky red to light gray and yellowish gray.	Light olive and light gray to medium gray; locally limonite stained to dusky red.	Pale red to olive gray; generally slightly darker than freshly broken surface.	Pinkish gray, very pale orange, grayish orange pink.	Light olive and light gray to very dark gray.	Light gray and medium light gray, grayish orange pink, and light brownish gray to pale red and moderate red, moderate orange pink and light brown.	Medium gray to light gray, grayish orange pink, limonite stained.	Light gray to very pale orange and pale yellowish brown.
Topographic expression.	Cliffs to slopes; largely ledgy cliffs and ledgy slopes.	Ledgy slopes, locally slopes and cliffs.	Cliffs and ledgy cliffs.	Caps cliffs and ledgy(?) cliffs.	Ledgy slopes; locally slopes and cliffs.	Cliffs and ledges; largely cliffs.	Ledge, caps cliff.	Slopes to cliffs.
Special features	Ripple marks. Shrinkage cracks. Pseudochannels (sparse). Preconsolidation features (sparse). Mud-plate conglcmerate (sparse). Fucoidlike markings.	Ripple marks. Shrinkage cracks. Pseudochannels. Preconsolidation deformation features (sparse). Fucoid-like markings (moderately sparse). Stylolites.	Ripple marks (rare). Shrinkage cracks (rare). Paleochannels. Preconsolidation deformation features. Fucoidlike markings (sparse). Stylolites.	Stylolites (sparse). Mud-plate or claygall conglomerate, locally present at base.	Shrinkage cracks (crumpled). Stylolites. High potassium content. (table 4). Low amplitude flexures. Ripple marks (rare).	Shrinkage cracks. Preconsolidation deformation features. Stylolites.	Locally pock marked.	
Diagnostic characteristics (when taken together).	Red color. Position above coarser grained strata of the lower member. Abundant detrital mica.	Gray color. Thin, irregular stratification typical of tidal or mud-flat deposits. Slope and ledgy	Cliff or ledge between ledgy slopes of gray and black facies. Preconsolidation distortion fea-	Light color. Medium to coarse grain size. Caps cliff. Nonlenticuarity.	Dark gray color. Crumbled shrinkage cracks. Thin, irregular stratification typical of tidal	Light color. Abundant cross-stratification. Preconsolidation deformation features. Cliff above	Light color. Caps cliff. Quartzose composition. Generally coarser grained than underlying	Even stratification. Above orthoquartzite of buff unit. Below poorly sorted sand-

		slope outcrop. Pseudochannels. Stratigraphic position.	tures. Thicker stratification and larger grain size than rocks above and below. Capped by barren quartzite.		or mud-flat deposits. Position below light-colored cliffs in many sections.	black facies.	rock.	stone or dolomite mudstone of Mescal.

DRIPPING SPRING QUARTZITE

The Dripping Spring Quartzite is composed largely of feldspar-rich silty, and arenaceous clastic rocks. The accepted lithologic term quartzite is not appropriate for most of the formation but has been retained herein to avoid complicating the literature. Although many of the strata are of orthoquartzite, most of the Dripping Spring consists of rocks too poorly cemented and too feldspathic to be properly termed quartzite. The Dripping Spring is faulted and altered at the original type section on Barnes Peak (Ransome, 1903). A section well exposed on the steep canyon walls of Deep Creek 0.7 mile north of its confluence with Bull Canyon (fig. 3) is more representative of the formation, and divisions of the formation presented in this paper are based on this and similar sections.

The Dripping Spring (fig. 4, fig. 3, table 2) can be divided into the Barnes Conglomerate Member, a middle member, and an upper member. The Barnes Conglomerate, previously considered to be a separate formation, is here redefined as the Barnes Conglomerate Member of the Dripping Spring Quartzite. The middle member, formerly called the lower member (Granger and Raup, 1959), is a succession of arkosic and feldspathic sandstones and orthoquartzites that overlies the Barnes. The upper member consists largely of arkosic and feldspathic siltstone and very fine grained sandstone.

The Dripping Spring, where fully developed in Gila County, ranges in thickness from about 450 to 708 feet (pl. 2). It is missing in parts of the county, however, because of both nondeposition and removal by erosion. Complete measured sections range in thickness from 323 to 708 feet. The thinnest sections were measured in the northwest and southeast parts of the county, and the thickest sections are in an eastward-trending belt across the center of the county.

BARNES CONGLOMERATE MEMBER

The Barnes Conglomerate Member is here considered to be the basal member of the Dripping Spring Quartzite rather than a formation as previously assigned by Ransome (1903). Stratigraphically and lithologically it constitutes the basal conglomerate of the Dripping Spring and is composed largely of well-rounded quartzose pebbles and cobbles in a medium- to coarse-grained feldspar-rich sandstone matrix; sandstone interstrata and lenses are common.

The abundant stones (see p. 75) in the Barnes Conglomerate Member readily distinguish it from the underlying Pioneer Formation. The Barnes is nearly conformable with the Pioneer in most places, even though there is generally some evidence of pre-Barnes erosion of the Pioneer. Paleochannels cut in the top of the Pioneer

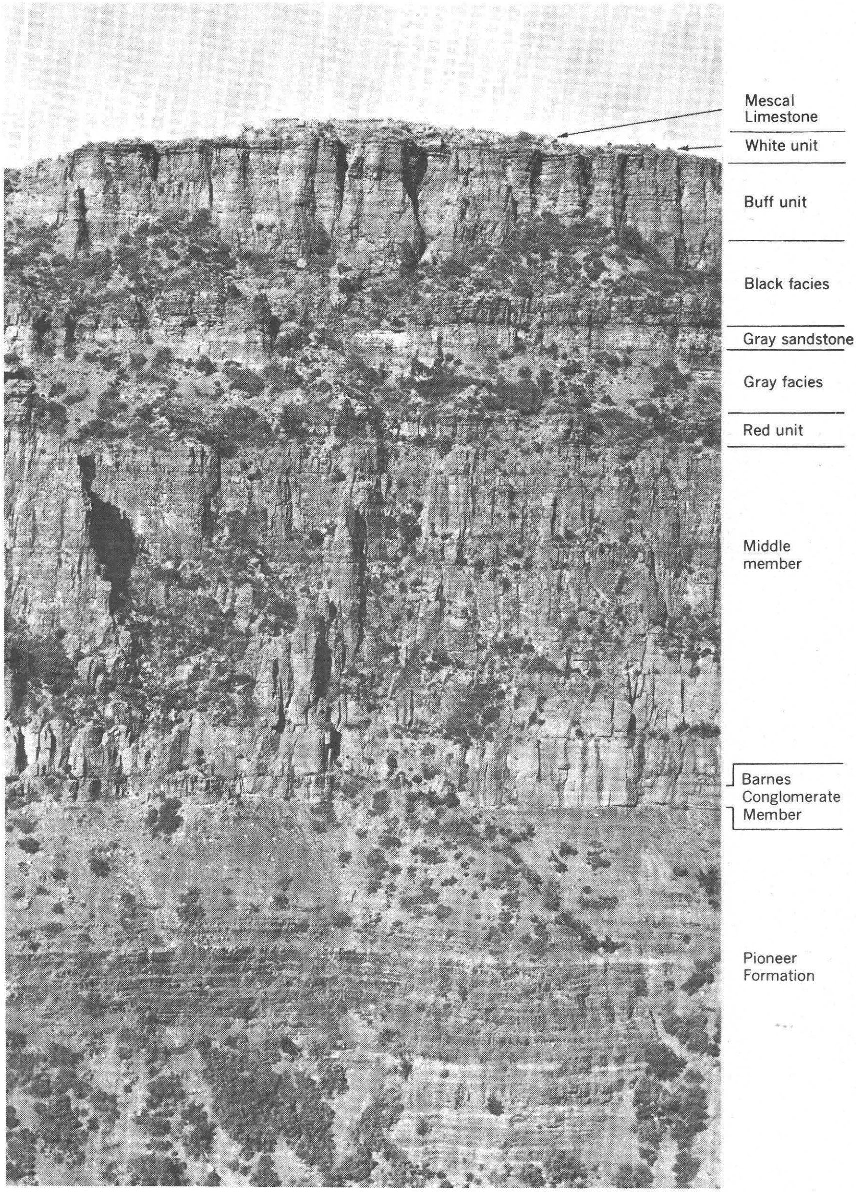

FIGURE 3.—Reference section of the Dripping Spring Quartzite, looking east across Deep Creek 3,500 feet north of its confluence with Bull Canyon, Gila County, Ariz. (See measured Bull Canyon section, p. 80, for description.)

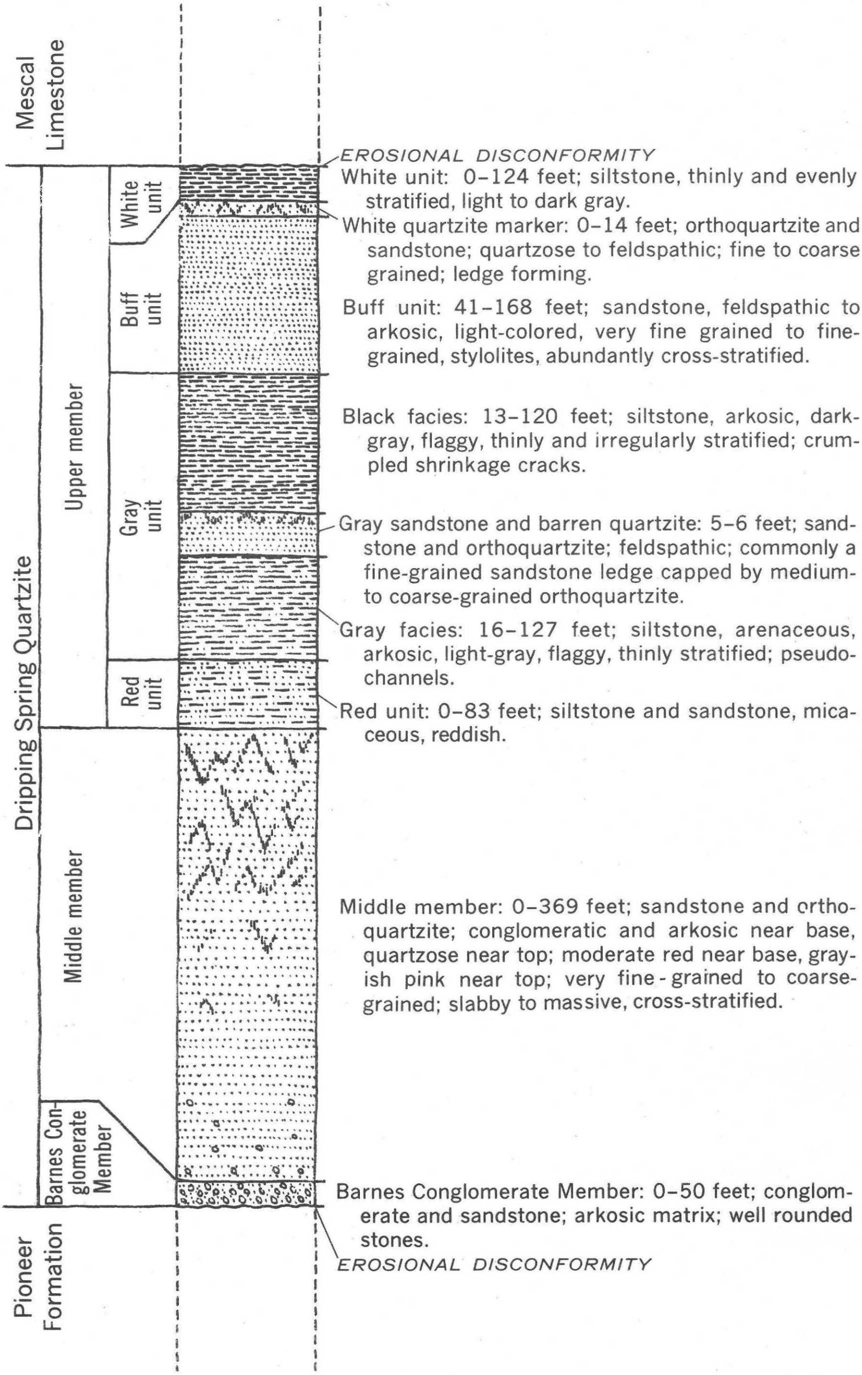

FIGURE 4.—Generalized columnar section of the Dripping Spring Quartzite, Gila County, Ariz.

and filled with conglomerate are common but are rarely more than 2 feet deep. Locally, however, structural unconformity at the contact has been noted. Gastil (1953) reported that the Pioneer dips as much as 30° in places where the Dripping Spring is nearly horizontal in the Diamond Butte quadrangle. Angular unconformities of 3° and 18° between the Barnes Conglomerate Member and Pioneer Formation were noted at the Copper Mountain section and about 10 miles southeast of Globe, respectively.

The top of the Barnes is readily apparent in most places. In some places, however, the base of the overlying quartzitic unit is also conglomeratic and here the division is ordinarily made at a prominent stratification plane above which stones make up less than 50 percent of the rock and below which most conglomerate strata contain more than 50 percent pebbles and cobbles.

THICKNESS

The thickness of the Barnes Conglomerate Member is inconsistent, although it commonly ranges from 5 to 20 feet. Thicker sections are known and locally it is absent. Along Cherry Creek in the Sierra Ancha, for example, the Barnes is as much as 50 feet thick (Sharp, 1956) even though there are 20 feet or less in exposures a few miles away. Other thick sections of Barnes are in the Dripping Spring Mountains where Ransome (1919, p. 41) noted about 40 feet, in the Tortilla Mountains (fig. 1) south of Gila County where it attains a thickness of 50 feet (Schwartz, 1954) or 55 feet (Ransome, 1919, p. 41), and in the Santa Catalina Mountains north of Tucson (fig. 1) where a cliff of Barnes more than 60 feet high was reported by Wallace (1951).

Gastil (1953) noted that the Barnes thins out and disappears northward in the Diamond Butte quadrangle, its position being marked by discontinuous strata of conglomerate. Enlows (1939) states that the Barnes thins to the southeast in the Little Dragoon Mountains, and Carpenter (1948) noted that the Barnes is missing in the southern part of the Vekol Mountains.

With the exception of these local pinchouts, the Barnes apparently has no consistent regional pattern of thickness. It ranges from a few feet to 20 feet in thickness in most areas of quadrangle size, and the sections that contain 50 feet or more of Barnes are so widely separated as to form no regional pattern.

SPLITTING PROPERTY AND STRATIFICATION

The Barnes Conglomerate Member is massive in most places, but is also blocky and slabby. Sets (p. 75) are generally structureless, but may be cross-laminated to thinly crossbedded where the matrix is more abundant than the pebbles and cobbles.

In some sections the Barnes consists of alternating blocky to slabby sets of conglomerate, conglomeratic sandstone and sandstone. The conglomerate sets are generally structureless, but the conglomeratic sandstones and sandstones are laminated to very thinly crossbedded.

GRAIN SIZE

The stones range in size from granules to cobbles, but pebbles are generally more abundant than the other sizes. Boulders are not present in the Barnes so far as is known, but they occur locally as subangular debris in similar conglomerates described below.

Descriptions of the Barnes in the Vekol Mountains (Carpenter, 1948), in the Slate Mountains (Hogue, 1940), and in the Little Dragoon Mountains (Cooper and Silver, in press) do not differ significantly in detail from descriptions of the Barnes throughout most of Gila County. Locally, certain sections seem to have no stones exceeding 3 inches across (Wallace, 1951; Galbraith, 1935) but nearby exposures almost invariably disclose a more normal assemblage of stones, some of which attain medium cobble size.

COMPOSITION

The stones are composed largely of quartzite and vein or pegmatite quartz; they commonly contain a small amount of jasper and, in a few sections, sparse fragments of feldspar and granite. About 65–75 percent of the stones in a typical section of Barnes are composed of pinkish to grayish tinted quartzite; 20–35 percent are white vein quartz; and less than 3 percent are moderate reddish-brown jasper. The composition varies widely, however. At the Copper Mountain section, for example, nearly 60 percent of the stones are composed of vein quartz; 40 percent are feldspar; and there are minor amounts of quartzite and granite. At the Barnes Peak section, on the other hand, nearly 80 percent of the stones consist of quartzite.

A few percent of the granules and small pebbles at the Copper Mountain, Natanes, Coolidge Dam, Canyon Creek, and Red Bluff sections consist of moderate reddish-orange feldspar. No stones consisting of feldspar were noted, however, in the other sections that we measured.

Specularite, as small vug and fracture fillings in the Barnes, is common and is particularly prevalent at the Natanes and Red Bluff sections.

SHAPE

Most of the stones are spheroidal, but their surfaces are commonly irregular and are rarely true spheres. Only a few stones are discoids, and blades and rollers are rare.

ROUNDNESS

The stones, particularly the quartzose pebbles and cobbles, are predominantly well rounded. The less abundant feldspar, jasper, and granite stones, which are mostly granules or small pebbles, are commonly only subangular or angular. The contrast of the well-rounded, resistant quartzose pebbles to the subangular, less resistant feldspar and granite stones suggests different source areas.

SEDIMENTARY STRUCTURES

Imbrication of stones in the Barnes is rare. Pebbles in the Natanes section seem to indicate southward-moving currents; imbrication in the section near Pioneer Stage Station would indicate currents that flowed about N. 20° W. Gastil (1953) noted that the cobbles slope to the east at Parker Creek, indicating a westward-flowing current.

BLAZES ON STONES

Where stones in the Barnes Conglomerate Member are not separated by abundant matrix, the points at which they touch are commonly marked by indentations or "blazes" (Gastil, 1953). These "blazes" are apparently caused by cementation at the points of contact between the stones. The points where the stones touched each other were points of solution and recrystallization due to the effect of differential pressure on the solubility of the quartz. Blazes on pebbles in the Barnes are common at Parker Creek, lower Canyon Creek, near Troy Peak in the Dripping Spring Mountains, and at Gerald Wash.

MATRIX

The matrix in the Barnes Conglomerate Member is arkosic to feldspathic sandstone. The quartz content ranges from 40 to 85 percent, and most of the remaining material is feldspar or alteration products of feldspar. The grain size ranges from fine grained to very coarse grained, but the average grain size of the matrix is medium or larger in all sections except Coolidge Dam.

The color of the matrix is governed by the feldspar content, iron oxides, and the degree of alteration and leaching. The fresh matrix generally ranges from moderate red to grayish pink. Weathered rocks, which ordinarily are darker because of iron oxides, range from grayish red to pale red; some of the bleached rock is light gray to pink.

The matrix and the sandstone interstrata are generally well indurated. Where the quartz content is high, the matrix breaks as a quartzite. Joints may or may not cut across the individual stones, depending somewhat on the induration of the matrix. Presumably, most joints that formed at depth cut the stones, but fractures formed near the present ground surface may be deflected around individual stones where the cementation is relatively weak.

Apparently no consistent regional variation exists in either the grain size or composition of the matrix. The matrix is arkosic throughout Gila County and to the southernmost exposures in the Little Dragoon Mountains (Cooper and Silver, in press) and Vekol Mountains (Carpenter, 1948).

OTHER CONGLOMERATES, POSSIBLY BARNES

In northwestern Gila County, subangular stones are present in conglomerates at or near the horizon of the Barnes. In the Diamond Butte quadrangle, Gastil (1953) noted that near "buried islands," of older rocks that projected through the Pioneer Formation at the time of deposition, the base of the Dripping Spring Quartzite is marked by stringers of fragments derived locally from the basement rock. Similarly, Ransome (1916, p. 156) working close to the area studied by Gastil, noted only 2 feet of angular conglomerate containing white quartz stones. These conglomerates are regarded in part as equivalents of the Barnes, inasmuch as the Barnes lenses out northward in this area; and Gastil found little or no conglomerate containing rounded stones typical of the Barnes away from the "buried islands."

The sharply contrasting stones of the Barnes Conglomerate Member and its locally derived equivalents have been found together at the Copper Mountain section, which is immediately south of the area studied by Gastil and Ransome. There the Barnes interval is marked by conglomerate composed of both well-rounded quartzite stones and angular and subangular granite and feldspar stones.

A subangular cobble and boulder conglomerate underlies rocks interpreted as upper member of the Dripping Spring at Haigler Creek; a similar conglomerate at Gordon Canyon was noted by Gastil (1953) and earlier by Darton (1925, p. 235, fig. 4). The conglomerate at Gordon Canyon may be an equivalent of the Barnes or Scanlan, but the conglomerate at Haigler Creek is open to question. At Haigler Creek the conglomerate is underlain locally with slight angular unconformity by a fine-grained pale-red arkosic sandstone that was not identified. This arkosic sandstone may be a unit in the Pioneer Formation or it may represent part of the middle member of the Dripping Spring. It seems to be identical lithologically with certain facies of the middle member elsewhere. About half a mile downstream, the arkose is missing and the angular conglomerate disconformably overlies the Mazatzal Quartzite. About a mile farther downstream, a very thin conglomerate (Scanlan(?) Conglomerate) composed of sparse, well-rounded quartzite and vein quartz pebbles overlies the Mazatzal(?) Quartzite and is in turn overlain by locally conglomeratic very fine grained sandstone and siltstone presumed to belong to the Pioneer Formation. Our brief reconnaissance disclosed no diagnostic relations, but it is obvious that the coarse angular conglomerate cannot be correlated with the Scanlan. Also, if the arkosic sandstone underlying the conglomerate belongs to the middle member of the Dripping Spring, the conglomerate cannot be equivalent to the Barnes.

MIDDLE MEMBER

The middle member of the Dripping Spring Quartzite overlies the Barnes Conglomerate Member conformably and, in many places, gradationally. In earlier reports (Granger and Raup, 1959; Neuerburg and Granger, 1960) the middle member constituted the lower member of the Dripping Spring and the Barnes was considered to be a separate formation. The middle member is typically a highly indurated medium-grained feldspathic orthoquartzite or sandstone, but it shows wide variation in grain size and composition. In the measured sections, the middle member ranges in thickness from about 140 feet at Coolidge Dam to nearly 370 feet at Roosevelt Dam; it may be missing in the Haigler Creek section.

Detailed descriptions of measured sections of the middle member are given at the end of the report. From these it may be seen that the middle member can be readily divided into strata of various character at each locality, but correlation among these strata in adjacent or distant sections is generally difficult or impossible.

Gastil (1953), attempted correlation of parts of the middle member in a series of sections from north of the Diamond Butte quadrangle south to the Pioneer Stage Station area in the Ray quadrangle. He subdivided the middle member into three parts, which he called the Alpha, Beta, and Gamma members, separated near buried hills by layers of angular conglomerate derived from the basement rock. Gastil's lower part, or Alpha member, was distinguished by a matrix that includes sericite and chloritic material. His middle part, or Beta member, was distinguished by ferruginous and siliceous cement and lack of an argillaceous matrix. His upper part, or Gamma member, was described as being less feldspathic than the lower two and as being cemented by the authigenic outgrowths of secondary quartz grains. At two localities in the southern Sierra Ancha, Gastil identified specular hematite and apatite in the cement.

Our field studies indicate that correlation of separate parts of the middle member should not be attempted without more detailed study. We believe that the distinctions Gastil used are too subtle to be generally valid in the field, and probably are not applicable to many sections, particularly near the margins of and outside Gila County.

As a general rule, all sections show an upward decrease of feldspar and an increase of grain size (fig. 5) in the middle member. The color and composition of the cement reflect the compositional change, being redder and more argillaceous in the lower strata and lighter and more siliceous in strata higher in the section.

SPLITTING PROPERTY AND STRATIFICATION

The middle member is most typically blocky, though slabby and massive strata are common. In general, the slabby and less common flaggy strata are more arkosic and argillaceous than the massive strata.

Cross-stratification is abundant, principally as small- and medium-scale cross laminae and very thin crossbeds. Because of the poorer sorting and the graded bedding the cross strata are more easily seen in feldspathic and arkosic strata than in the more uniform orthoquartzite. The base of a cross stratum in arkosic rocks is generally coarser grained and more quartzose than the top. In orthoquartzite, cross-stratification may be very obscure because of the purity and better sorting; it may be so obscure that the strata appear structureless.

GRAIN SIZE

Grain sizes in the middle member range from clay to pebbles, and the average grain size is slightly less than medium. Although the basal strata of the member are conglomeratic in some places, the matrix and nonconglomeratic strata are typically fine and very fine grained, particularly if they are rich in feldspar. Medium-grained interstrata are not uncommon, and they become more abundant toward the top of the unit. In some sections the grain size and quartz content decrease again in the upper few feet of the member. Orthoquartzite and feldspathic quartzite strata, commonest in the upper half of the member, are medium to very coarse grained. As a general rule, the more quartzose strata are the coarser grained, and these are most abundant toward the top of the middle member.

COMPOSITION

The middle member is composed almost entirely of quartz and feldspar. As a general rule, at least some of the quartz grains have wavy extinction in thin section and others are composed of finer sutured quartz grains, indicating derivations from a metamorphic terrane. The more quartz there is in the rock, the larger the grain size. The feldspar is largely obscurely twinned microcline, but low-index plagioclase is recognizable in most thin sections. Other detrital

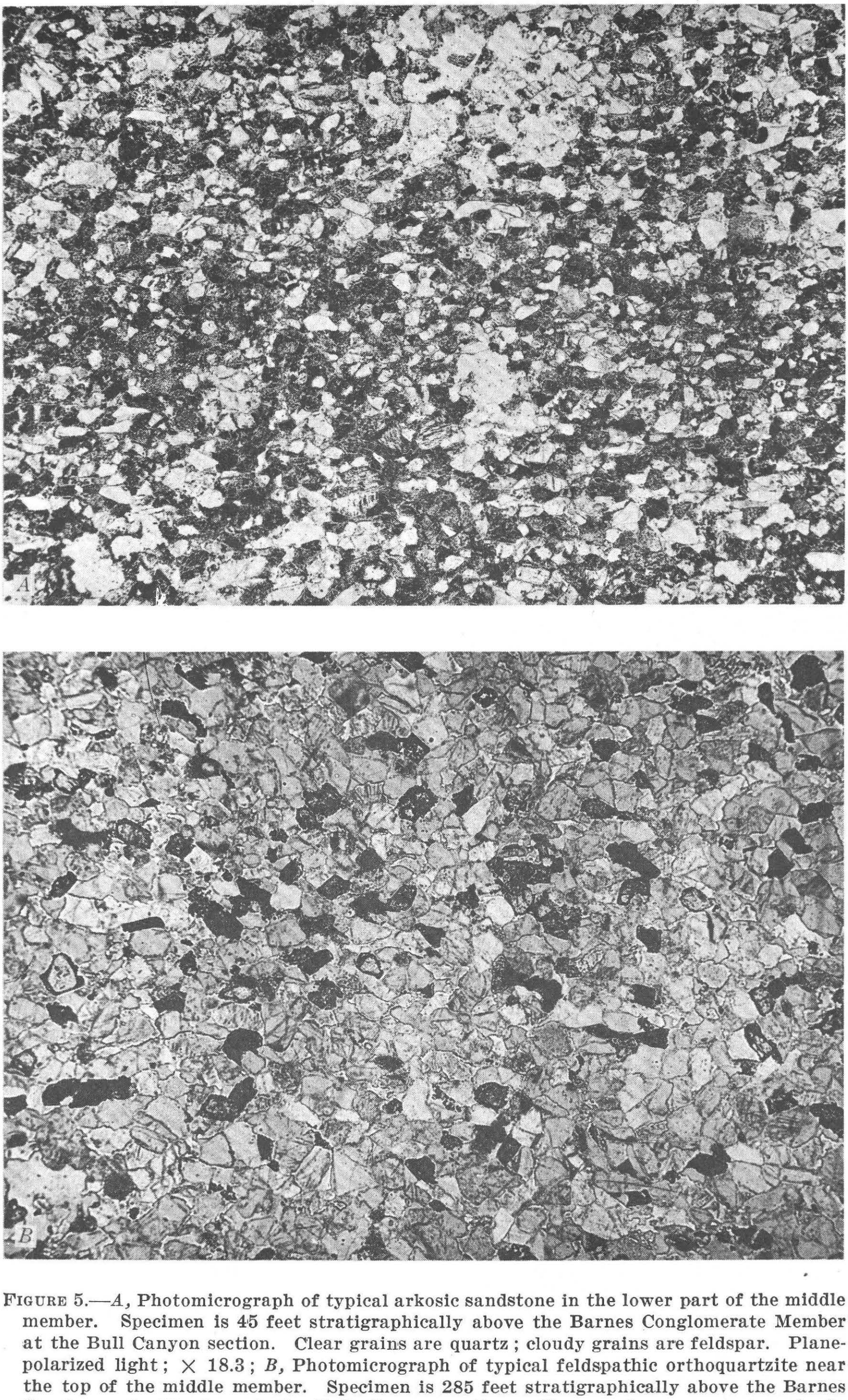

FIGURE 5.—*A*, Photomicrograph of typical arkosic sandstone in the lower part of the middle member. Specimen is 45 feet stratigraphically above the Barnes Conglomerate Member at the Bull Canyon section. Clear grains are quartz; cloudy grains are feldspar. Plane-polarized light; × 18.3; *B*, Photomicrograph of typical feldspathic orthoquartzite near the top of the middle member. Specimen is 285 feet stratigraphically above the Barnes Conglomerate Member at the Bull Canyon section. Clear grains are quartz; cloudy to near-black grains are feldspar. Plane-polarized light; × 18.3.

minerals, generally totaling less than 5 percent of the rock, are rutile, magnetite, zircon, apatite (Galbraith, 1935; Harshman, 1939), and very rarely schorlite, sphene (Harshman, 1939), and muscovite. The schorlite was seen only in two thin sections from the Bull Canyon area. Among the secondary minerals are various clays, hematite (specularite in part), limonite, sericite, leucoxene, carbonate minerals, and chert. Gastil (1953) identified apatite in the cement near the top of the middle member at Red Bluff and Parker Creek. Gastil also noted a birefringent chloritic mineral in the matrix near the base of the middle member. A mineral that is presumably the same has been noted by us at Red Bluff and Bull Canyon. It has the following properties: yellow, fibrous or micaceous, faintly pleochroic, first-order birefringence, length slow, high relief, common association with limonite.

COLOR

The color of the middle member is influenced by several factors, including surface stains of iron oxides, degree of weathering, and the presence of minute inclusions of iron oxide in authigenic overgrowths on feldspar grains. The color of the fresh rock, however, is controlled in large part by the content of moderate reddish-orange feldspar grains. Although many exceptions exist, a general "rule-of-thumb" in the field is as follows:

Relation of color to feldspar content of middle member

Feldspar content (percent)	*Fresh color*	*Weathered color*
0–20	Pale red to grayish orange pink.	Moderate orange pink.
20–40	Pale red	Pale red to grayish orange.
40–60	Moderate reddish orange	Moderate reddish-orange to grayish-orange pink.
60–80	Grayish red to moderate red	Grayish red to pale red.

Because color is related to feldspar content, the basal strata of the middle member are ordinarily redder than the upper strata. Weathered rock is darker than the fresh rock, except where bleaching may have reversed this relation. Where the rock is highly fractured, meteoric and hydrothermal solutions have altered the feldspars to clay and sericite and, in some places, have removed much of the iron and other coloring matter.

CEMENTATION

The degrees of induration and cementation are commonly proportional to the quartz content. The orthoquartzites and feldspathic sandstones are generally much harder than the arkosic sandstones. Authigenic quartz overgrowths and recrystallized quartz form the strongest cement and are most common in the purer orthoquartzites.

Authigenic overgrowths on feldspar grains are also important as cement in the more feldspathic rocks. Quartz, as overgrowths and cryptocrystalline cement, is generally relatively free of inclusions except at the margins. The rounded outlines of many original quartz grains are visible as "ghosts" in thin sections and are surrounded by the overgrowths in optical continuity. The boundaries between overgrowths on adjacent grains are either sutured or mutual. Against altered feldspars or clay, chlorite, and other fine-grained alteration minerals, the overgrowths terminate with a very irregular poikiloblastic texture. Many quartz grains with irregular outlines contain no ghosts of the original grains, or the original outline is present only through a small arc. Some of these grains may be partly or completely recrystallized.

Overgrowths surrounding original detrital feldspar grains are also common. The overgrowths are clouded with dustlike inclusions of hematite(?) and alteration minerals. Indices of the authigenic material are in the K-feldspar range but may form overgrowths on the plagioclase as well as on alkali feldspars. The margins of the overgrowths generally grade into the surrounding matrix.

Other cements, although less common and probably less effective than the overgrowths, are various clay minerals, chert, carbonate minerals, limonite, hematite, and, according to Gastil (1953), apatite.

SURFACE EXPRESSION

Outcrops of the middle member are ordinarily very rugged. Nearly vertical cliffs bordering narrow canyons are a characteristic expression of the member in the Sierra Ancha and Mescal Mountains. In the Globe-Miami area, the surface expression may be subdued owing to intense alteration and shattering.

Weathered surfaces of the middle member range from smoothly rounded to hackly. The well-cemented orthoquartzites generally form the smoothest surfaces, especially where water worn. The surface of certain orthoquartzitic strata, particularly near the top of the member, is pockmarked with shallow indentations about 1 inch in diameter. These indentations were small concretionary zones cemented by iron minerals in strata that are otherwise cemented by quartz. Weathering and oxidation of the iron-rich cement resulted in pockmarks at the surface.

SEDIMENTARY STRUCTURES

Primary sedimentary structural features in the middle member consist of cross strata, ripple marks, and shrinkage cracks. Planar cross-stratification, in which the lower bounding surfaces of sets are

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planar surfaces of erosion (McKee and Weir, 1953), is the most common type. Less abundant are examples of trough cross-stratification in which the lower bounding surfaces of sets are curved surfaces of erosion. Gastil (1953) notes that his Beta member in the Diamond Butte quadrangle is typified by a facies of compound cross-lamination. These are probably trough cross strata as defined by McKee and Weir. The lower bounding surfaces on the trough cross strata are generally only gently curved, so that they are gradational into planar types. Most of the cross-stratification in the middle member is small or medium scale, low angle, concave tabular, and planar, following the definitions of McKee and Weir (1953). Large-scale high-angle cross strata were observed in the Copper Mountain section but are rare elsewhere.

Nearly all the ripple marks in the middle member are near the top. They occur in thin or very thin beds of graded silicified arenaceous siltstone that cap sets of cross-laminated sandstone and orthoquartzite. Most of the ripple marks consist of irregularly spaced cusp-shaped depressions about 4 to 12 inches across. Wave or current ripple marks consisting of subparallel ridges and furrows are scarce.

Shrinkage cracks, although scarce in the quartzitic unit, occur locally in the silicified, graded, silty laminae that cap many of the coarser grained sets and cosets near the top of the unit. They generally form typical polygonal patterns on stratification planes and are only a fraction of an inch deep.

RADIOACTIVITY

Radioactivity of the middle member and Barnes Conglomerate Member is less than that of the upper member but it is several times higher than minimum background radioactivity. Magleby and Mead (1959) measured the radioactivity with an airborne scintillation meter calibrated in microamperes. Radioactivity of the middle member and the Barnes ranged from 250 to 350 microamperes as contrasted with 75 microamperes over water and 375 to 500 microamperes over granite. Our ground surveys with a portable scintillation meter during the course of measuring the sections indicated that radioactivity in the middle member and Barnes usually ranges from 0.015 to 0.04 mr per hr (milliroentgens per hour). This contrasts with 0.008 to 0.015 mr per hr in diabase and 0.021 to 0.07 mr per hr in the upper member.

In some sections, as at Red Bluff, the middle member contains thin indurated mudstone lenses that reach 0.05 mr per hr. Gastil noted two localities in the Diamond Butte quadrangle in which ironstone concretions near the top of his Alpha member in the lower part of the Dripping Spring are radioactive. The radioactivity is reportedly due to authigenic xenotime. He also noted a radioactive conglomerate composed of devitrified fragments of glass in the middle member at Gerald Wash.

UPPER MEMBER

The upper member is a thinly stratified sequence of silty to fine-grained clastic rocks that, in most places, overlies the middle member with apparent conformity. The member has been subdivided into four units that can, with few exceptions, be correlated throughout Gila County. These units are, from bottom to top, the red, gray, buff, and white units. The gray unit is further subdivided into the gray facies, the gray sandstone capped by a barren quartzite, and the black facies. The buff unit is capped by a subunit called the white quartzite marker.

Gastil (1953) divided the upper member into three parts called the lower (red) member, middle (gray) member, and the upper (light) member. His divisions in general correspond to those used herein, and we have adopted a part of Gastil's terminology in referring to the red, gray, and buff units; we have, however, recognized an additional unit at the top of some sections which we have termed the white unit. Gastil further subdivided his middle (gray) member into a lower gray submember and a black facies separated by a 6-foot-thick sandstone. These correspond to our gray facies and black facies separated by the gray sandstone. The gray sandstone is capped by a thin orthoquartzite, barren quartzite, has proved to be an extremely useful marker unit throughout Gila County. The topmost orthoquartzitic strata in the buff unit are here called the white quartzite marker after Kaiser (1951).

The basal strata of the upper member are distinguished from the lower member by three criteria: (a) the strata are largely flaggy, laminated, and very thin bedded in contrast with predominantly blocky, cross-stratified rocks below; (b) the strata are generally arenaceous siltstone in contrast with underlying fine- or medium-grained sandstone; and (c) mica is a common though not abundant constituent, particularly of the basal red unit of the upper member.

The upper member is everywhere underlain by the middle member except in the extreme northern part of the outcrop area near Gordon Canyon and Haigler Creek. At the Haigler Creek locality about 108 feet of silty strata above the angular conglomerate and below the gray unit cannot be correlated with other measured sections. The lithology of these strata closely resembles upper member lithology elsewhere, and it may be a separate unit locally present only near the margin of the basin. Because of the uncertain correlation, these strata were omitted in calculating the thickness of the upper member for preparation of table 3 and the isopach map shown in figure 20.

In the upper member, the thickest sections measured (pl. 2; table 3), slightly less than 400 feet thick, were in Potts Canyon and at Barnes Peak. Most sections in Gila County range from about 240 to 400 feet thick. The thinnest section measured, approximately 180 feet thick, was at Coolidge Dam. The member may wedge out a few miles to the southeast.

TABLE 3.—*Thickness of the upper member, Dripping Spring Quartzite, Gila County, Arizona*

[In feet. M, missing; I, incomplete]

Locality	Red unit	Gray unit				Buff unit	White unit	Total
		Gray facies	Gray sandstone	Black facies	Total gray unit			
Barnes Peak and North Barnes Peak	74	147		67	214	98	10	396
Bull Canyon	35	65	19	106	190	103	10	338
Canyon Creek	6	43	33	24	100	104	(M)	210
Cherry Creek	3(?)	57	25	100	182	100	(M)	285
Coolidge Dam	58	27	16	13	56	61	5	180
Copper Mountain	(M)	70	31	82	183	120	35	338
DeVore Wash	31	84	17	41	142	31(?)	----------	(I)
Gerald Wash	63	65	57	81	203	91	(M)	357
Haigler Creek	(?)	37		44	81	102	31	214
Nataines	70(?)	45(?)	5	96	146(?)	113(?)	(M)	329(?)
Pioneer	83(?)	127	11	107	245	41	(M)	369
Potts Canyon	80	85	61	118	264	50	3	397
Red Bluff	36	62	17	101	180	110	11	337
Regal Canyon	20	62	38	107	207	60	(M)	287
Roosevelt Dam	20	60	6	65	131	168	3	322
Snakebit claim	34	46	38	107	191	49	13	287
Walnut Creek	16	58	34	62	154	146		316
Wilson Creek	(M)	18		120	138	78	20	236
Workman Creek	----------	33+	24	101	158+	85	124	(I)

RED UNIT

The red unit, where present, is the basal unit of the upper member, and in most sections it is easily distinguished from the orthoquartzitic strata of the underlying middle member.

In general the red unit is composed of interstratified hematitic micaceous siltstone and very fine grained sandstone. The siltstone strata commonly have a shaly to massive splitting property, depending to some extent on the quantity of muscovite concentrated along bedding planes. Stratification is largely laminated to thinly laminated. The interlayered sandstones are broadly lenticular. The splitting property ranges from flaggy to slabby. Stratification in the sandstone is obscure; it may be cross laminated, but generally little can be seen other than the splitting property.

The red unit, where fresh, is light gray, pale red, or pale reddish brown. Not uncommonly the siltstone layers are gray and the sandstones pale red, giving a banded appearance to the rock. The weathered surfaces are very dusky red to light gray and yellowish gray. Where diabase has intruded near the red unit the rock is locally somewhat bleached, and in places this results in a resistant cliff of abnormally colored rock difficult to recognize as the red unit.

Detrital quartz and potassic feldspar are the most abundant constituents of the rock. Detrital muscovite and very finely divided hematite, diagnostic of this unit, are almost invariably recognizable megascopically. A little ilmenite and magnetite can be distinguished in most specimens. Secondary minerals consist of minor amounts of jarosite, calcite-dolomite, illite, and leucoxene.

The rock is moderately to well indurated. The sandstone lenses may be well indurated to quartzitic. Much of the cementation is by a fine-grained aggregate of jarosite-hematite; carbonate minerals and illite clay are of less importance as cementing agents.

The shaly siltstone contains small platy fragments of similar rock, in some places forming thin lenticular "mud plate" conglomerates (fig. 6). The fragments doubtless represent material loosened by shrinkage cracks and incorporated in the succeeding depositional layer.

Ripple marks are common in the red unit. They are generally cusp-shaped, but some are of the current or oscillation variety.

Outcrop characteristics of the red unit are not consistent and depend on both the abundance of well-indurated sandstone in the unit and

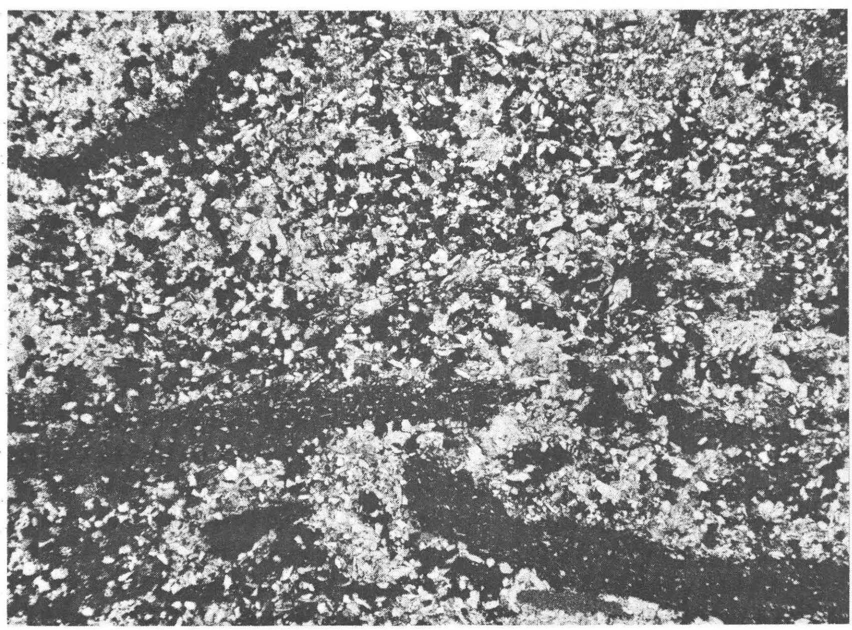

FIGURE 6.—Photomicrograph of rock from the red unit, Coolidge Dam section. Elongate fragments are siltstone and shale plates derived from underlying strata. Clear grains are quartz; cloudy grains are a mixture of altered feldspar, clay, hematite, and mica. Plane-polarized light; × 18.3.

the outcrop characteristics of underlying and overlying rocks. Ordinarily the red unit forms a steep slope with ledges on the sandstone lenses. In steep-walled recently-cut canyons the red unit may form irregular cliffs. Surfaces that have been exposed to long weathering result in rubble-covered slopes.

Measured sections of the red unit range in thickness from 6 to 83 feet. The red unit is absent in the more northwesterly sections and the unit becomes generally thicker to the south and southeast.

In most sections the red unit can be divided into two parts. The lower of these contains a large amount of siltstone relative to the very fine grained sandstone lenses. In the upper part the reverse is true. The ratio of thickness of the upper part to the lower part increases in a general way to the southwest.

GRAY UNIT

The gray unit, which comprises the gray facies, the gray sandstone and barren quartzite, and the black facies, has received more detailed study than any other part of the Dripping Spring because of its importance as the host rock for the primary uranium deposits. For the most part the unit is composed of highly arkosic siltstone or fine grained sandstone, and much of it contains enough finely divided carbon to make the fresh rock distinctly gray to nearly black.

Total thickness of the gray unit ranges from 56 to 264 feet in the measured sections. The thinnest sections are near the inferred margins of the Apache embayment (p. 68) at Naigler Creek and Coolidge Dam.

GRAY FACIES

The gray facies overlies either the red unit or the middle member with apparent conformity. A rather abrupt change of color distinguishes it from the red unit in relatively unmetamorphosed sections; the fineness of grain size and the presence of mica readily distinguish it from the middle member. It is recognized more by its position between the underlying rocks and the gray sandstone than by any consistent distinguishing characteristics except possibly pseudochannels. (See p. 47.) In many sections, however, it was not readily separable from the gray sandstone and they were described together.

The general aspect of most of the gray facies is of a thinly stratified siltstone with local intercalated very fine to fine-grained sandstone strata. Grain size is mostly in the silt to very fine grained range, but local fine-grained lenses are present, particularly near the base of the facies.

Stratification of the gray facies ranges from thin laminated to very thin bedded. Wispy cross-lamination (p. 76) is common in the very fine grained strata, and planar cross-lamination was noted in some of the fine-grained sandstone lenses. The splitting property is largely flaggy but ranges from papery to blocky. The finest material generally has the thinnest splitting property.

The fresh rock is predominantly light to medium gray. Weathered outcrops range from light gray through olive gray to medium gray where not strongly limonite stained. Most surfaces have some limonite stain and may be as dark as dusky red.

Detrital minerals in the gray facies are feldspar and quartz and lesser amounts of muscovite, clay minerals, and rare zircon. Potassic feldspar, largely untwinned but some with grid twinning, is the dominant constituent. In some samples a little plagioclase is recognizable by both optical and X-ray methods. Quartz is universally present, but generally in lesser amounts than potassic feldspar. The feldspar-quartz ratio ranges from about 3:1 to 5:1 in much of the rock. Muscovite is present in many of the siltstone strata but is much less prevalent than in the red unit. Probably some of the clay is detrital, but some of it may represent alteration of the feldspar and mica. Carbon, as extremely finely divided and disseminated particles, is also present but may not have had a detrital origin. Secondary minerals in the fresh rock consist of clays, pyrite, and rare carbonate.

The K_2O content of the gray facies is probably nearly as high as that of the black facies (p. 36). Although no chemical analyses were made, semiquantitative spectrographic analyses of several samples indicate that the potassium content is near 10 percent.

The gray facies is ordinarily well indurated. In fresh rock the most effective cements are silica and authigenic overgrowths on feldspar. Clay, generally illite, forms a cement locally. Secondary iron oxides are of some importance as cementing agents near the weathered surface.

Structural features such as ripple marks, shrinkage cracks, stylolites, and fucoidlike markings are present but not abundant in the gray facies. Pseudochannels are common in places, and although undulating warps presumably related to the pseudochannels have been seen elsewhere in the upper member, only the gray facies contains pseudochannels with well-defined cores.

In outcrop the gray facies most commonly forms a steep slope with local subdued ledges; however, where the gray facies is held up by the resistance of overlying rock or by induration from diabase metamorphism, it forms a cliff.

The thickness of the gray facies in Gila County ranges from about 16 to 127 feet and averages about 65 feet. There is no apparent pattern to the thicknesses of the facies in different parts of the County.

GRAY SANDSTONE

The gray sandstone is not easily distinguished in many sections but where recognizable it is characterized by (a) thicker stratification and coarser grain size than the gray or black facies, (b) more resistant outcrop characteristics than adjacent facies, (c) preconsolidation distortion structures at the base, and (d) barren quartzite at the top.

The gray sandstone is largely a very fine to fine-grained slabby feldspathic sandstone or orthoquartzite; medium-grained sandstone lenses and siltstone splits are not uncommon. The splitting property ranges from flaggy to blocky but is largely slabby. Strata are largely laminated and very thin bedded but in places they are thick bedded. Some of the apparently thick-bedded strata are obscurely cross laminated.

The fresh rock is largely pale yellowish brown but ranges from pale red to olive gray. The color of weathered outcrops is similar but slightly darker.

Composition is similar to that of the gray facies except that carbon is scarce or absent. Quartz is ordinarily more abundant than feldspar and much of the rock is a feldspathic sandstone or orthoquartzite. The rock is well indurated to quartzitic. Silica or quartz overgrowths are the most important cement, and feldspar overgrowths and clay are important in some strata.

In several sections, notably at Red Bluff and Snakebit, the lower 2 to 4 feet of the gray sandstone is strongly distorted by preconsolidation movement. The strata were abruptly warped to vertical and overturned positions and were planed off prior to deposition of the succeeding strata.

Structural features such as ripple marks and shrinkage cracks are scarce if not absent in the gray sandstone.

Large channels noted in the gray sandstone are best exemplified by the well-exposed channel in Walnut Creek Canyon (fig. 7) about 7 miles southeast of Young. The bottom is cut in or at the top of the gray facies, and the top of the fill is directly under the black facies. The channel is about 200 feet wide and 33 feet deep as exposed on the canyon wall, and it trends northwestward. The fill is largely siltstone and sandstone strata that contain no conglomeratic material. The direction of flow of the scouring and depositional agents could not be determined.

Another channel considered to be in the gray sandstone is exposed on the north wall of Blevins Canyon in the Roosevelt quadrangle. Here the red unit and most of the gray facies apparently are missing and the channel is cut into the top of the middle member. At the base of the channel is a thin layer of conglomeratic sandstone consisting largely of angular and subangular granules and small pebbles of locally derived quartzite and siltstone. Above this the channel is filled with interstratified arkosic and feldspathic orthoquartzite similar to units in the middle member and siltstone similar to the gray facies of the upper member. The channel is about 700 feet wide and 50 feet deep. It apparently trends northward but the direction of flow at the time of deposition was not determined.

A third channel is poorly exposed at the confluence of Cherry Creek and China Spring Creek in the McFadden Peak quadrangle. The depth is roughly estimated to be 15 feet but the width and trend could not be determined. The exact stratigraphic position was not determined but may also be in the gray sandstone. In outward appearance this channel is similar to the one in Walnut Creek.

The thickness of the gray sandstone where it has been distinguished as a subunit ranges from 5 to 61 feet, but 20 to 30 feet is more characteristic. The thickness apparently has no regional trend in Gila County. For example, the Roosevelt Dam section has only 6 feet of gray sandstone, although it is between the Copper Mountain and Potts Canyon sections, which have 31 and 61 feet of gray sandstone, respectively.

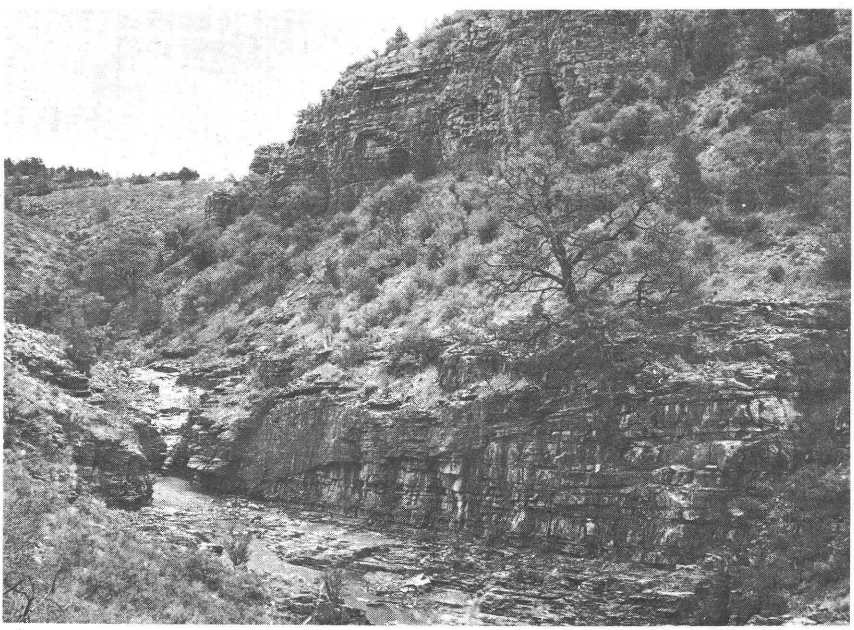

FIGURE 7.—Channel deposit in the gray sandstone at Walnut Creek. The bottom of the channel is at the lower left; the dead tree is approximately at the top. Scale is indicated by the man at the base of the cliff below the tree.

Capping the gray sandstone is a thin set or stratum of medium- to coarse-grained orthoquartzite—a barren quartzite—generally unmineralized even where a uranium deposit is present in the immediately overlying black facies or in the underlying gray facies. Many of the uranium deposits in the black facies seem to terminate at the top of the barren quartzite. The barren quartzite ordinarily consists of one or more slabby strata of medium- to coarse-grained orthoquartzite, and it rarely exceeds 2 feet in thickness. Some of the quartz grains have wavy extinction or consist of finer sutured grains, indicating a metamorphic source rock. The basal few inches of the barren quartzite contain platy light-colored silt or claystone fragments as much as 1 inch across at several places in the Sierra Ancha. The barren quartzite has been recognized at most uranium deposits, where it provides a good stratigraphic marker, but it was not recognized in some of the measured sections.

BLACK FACIES

The black facies is predominantly a medium dark-gray laminated siltstone with a few interstratified lenses of coarser grained sandstones, particularly near the base. Stratification ranges from very thinly laminated to thin bedded, but is mostly laminated. Sandstone and orthoquartzite lenses near the base of the facies may be cross-laminated, and some of the siltstone shows wispy cross-lamination.

The splitting property of the black facies varies from outcrop to outcrop. In drill cores the splitting property is commonly massive or blocky. Weathering, however, has the effect of destroying the cementation along certain planes of stratification that are rich in pyrite, carbon, mica, or clays, and thus the splitting property at the surface ranges from papery to blocky. Pyrite-filled stylolites are particularly susceptible to surficial oxidation, which commonly results in a flaggy or platy outcrop.

The fresh rock ranges from very light gray to dark gray. In some places almost the entire facies is medium gray to dark gray; in others, light-gray laminae alternate with dark-gray laminae. Very thin to thin beds are commonly graded from very fine grained sandstone at the base to silt at the top. In these the silt may be dark gray and the sandstone light gray to very light gray; the gray is largely due to the presence of very finely divided carbon and, to a lesser extent, pyrite.

The black facies has a most unusual composition for a fine-grained detrital sedimentary rock. To the best of our knowledge no other detrital sedimentary rock is consistently so rich in potassium. The K_2O content of 7 samples from the black facies at widely separated localities ranged from 10.5 to 14.6 percent (tables 4 and 6). The potassium is contained almost entirely in feldspar, which constitutes about 60 to 90 percent of the siltstone (fig. 8).

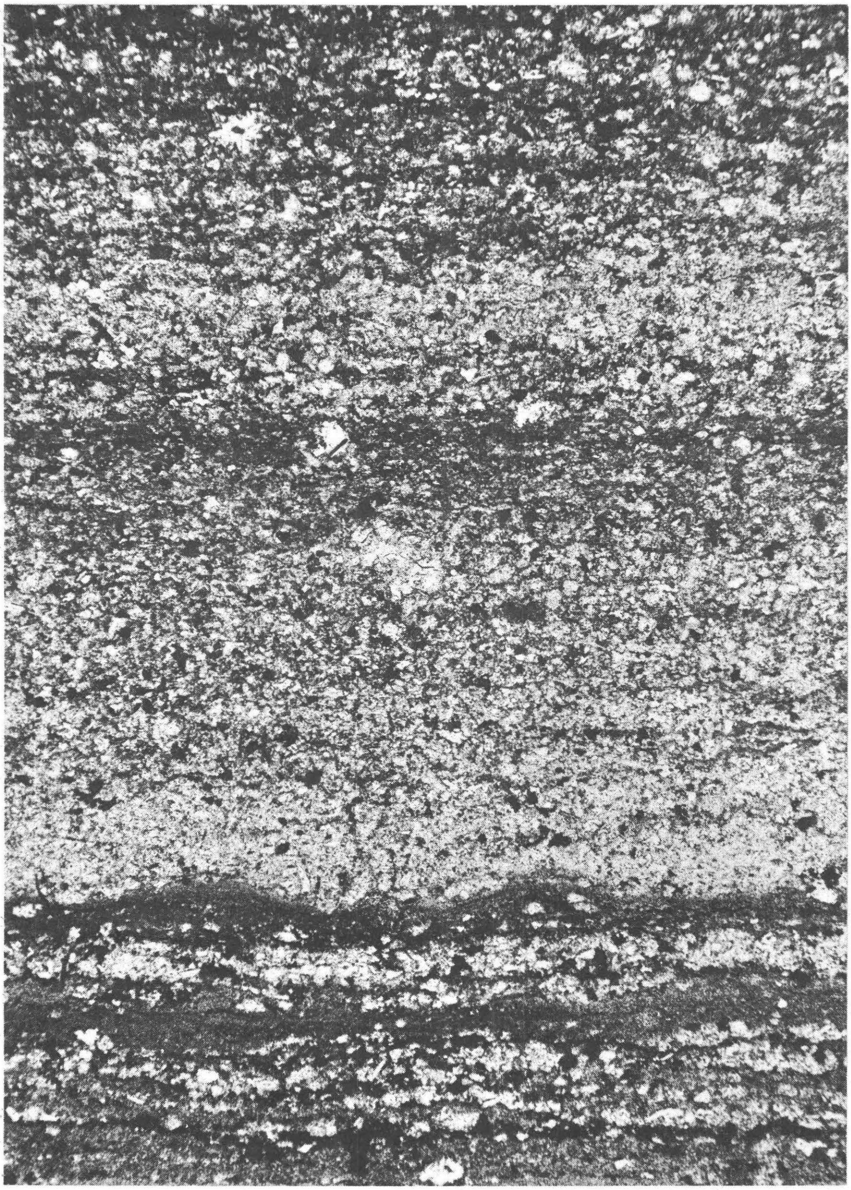

FIGURE 8.—Photomicrograph of texture typical of the black facies, Wilson Creek section. Largest clear grains are quartz; remainder of nonopaque grains are largely altered feldspar. Each grain is surrounded by fine "dust" of carbon. Larger black grains are pyrite. Plane-polarized light; × 29.

TABLE 4.—*Analyses of the black facies, upper member, Dripping Spring Quartzite*

Semiquantitative spectrographic analyses [1] (M=major constituent, greater than 10 percent)				Chemical analyses (weight percent)		
	1	2	3		4	5
Si	(M)	(M)	(M)	SiO_2	59.4	57.9
Al	(M)	(M)	(M)	Al_2O_3	14.7	14.8
Fe	7	1.5	3	Fe_2O_3	3.7	.5
				FeO	.35	6.8
Mg	3	.3	1.5	MgO	1.0	1.8
Ca	.3	.3	.3	CaO	1.8	.40
Na	.3	.7	.3	Na_2O	.18	.17
K	7	(M)	7	K_2O	12.4	11.7
Ti	.3	.3	.7	TiO_2	.86	.86
				P_2O_5	.11	.08
Mn	.015	.007	.03	MnO	.02	.05
				H_2O	.77	2.0
				CO_2	2.5	.51
				S	2.7	2.7

[1] Figures are reported to the nearest number in the series 7, 3, 1.5, 0.7, 0.3, 0.15 * * *, in percent. These numbers represent midpoints of group data on a geometric scale.

Comparisons of this type of semiquantitative results with data obtained by quantitative methods, either chemical or spectrographic, show that the assigned group includes the quantitative value about 60 percent of the time.

Sample	*Field No.*	*Locality*	*Analyst*
1	125G54	Snakebit section	P. J. Dunton.
2	128G54	Workman Creek area	N. M. Conklin.
3	106G55	Red Bluff area	R. G. Havens.
4	141G54	Wilson Creek section	P. L. D. Elmore, K. E. White, S. D. Botts.
5	33G53	Cherry Creek canyon	Do.

NOTE: Chemical analyses distinguishing between Fe_2O_3 and FeO are considered to be unreliable in rocks containing carbon and sulfide minerals.

The potassic feldspars in the black facies were studied optically and by means of the X-ray diffractometer. The normal feldspar is monoclinic and untwinned; its optic angle is moderate to large, and its composition is near $Or_{95}(Ab+An)_5$. It is apparently a very pure variety of orthoclase or, perhaps, adularia. Because of the low proportion of Ab in solid solution in this feldspar, it can be assumed that it was formed either at low temperatures or in a nearly soda-free environment. Igneous, pyroclastic, and metamorphic sources ordinarily provide potassic feldspars with a much higher soda (Ab) content. It is likely, therefore, that the feldspar formed diagenetically as an authigenic potassic alteration of detrital clay minerals (Gruner and Thiel, 1937).

Other primary constitutents of the black facies are a significant amount of quartz, possibly some clay, and minor amounts of plagioclase, muscovite, carbon, and sparse zircon. Both illite and montmorillonite have been identified by X-ray, and minute quantities of kaolin clays and perhaps allophane have been seen in thin section. The carbon is extremely finely divided and makes up as much as 3.4 percent of the darker rock (table 5), but it is absent in the lighter colored varieties of the rock. The particle size of the carbon is probably less than 1 micron and is certainly less than 10 microns.

Among the authigenic minerals, clays are the most abundant; pyrite is present as finely divided particles in much of the darker gray rock; and minor amounts of leucoxene, limonite, and carbonate minerals have been noted. The limonite becomes increasingly prevalent as the pyrite is oxidized by weathering processes. Not uncommonly an interface containing jarosite can be observed between fresh pyritic rock and weathered limonitic rock.

The black facies is generally well indurated. Cementation is ordinarily provided by clay, authigenic overgrowths on the feldspar, and iron minerals. In the more quartzose strata, authigenic overgrowths on the quartz grains are also important as cementing agents.

TABLE 5.—*Carbon content of medium-gray to dark-gray siltstone of the black facies, upper member, Dripping Spring Quartzite*

[NR, not reported]

Field No.	Locality	Analyst	Total carbon (percent)	Carbonate carbon (percent)	Organic carbon (percent)
128G54	Workman Creek area.	A. B. Caemmerer.	(NR)	(NR)	0.66
141G54	Wilson Creek section.	do	(NR)	(NR)	1.12
127G55	Pioneer section	J. P. Schuch	1.6	<0.1	1.6
133G55	Red Bluff area	do	1.2	<.1	1.2
140G55	Canyon Creek section.	do	<.5	<.1	<.5
145G55	Copper Mountain section.	do	4.1	.7	3.4
84G56	Haigler Creek section.	do	.5	<.1	<.5

Shrinkage cracks and stylolites are common in the black facies, but ripple marks are scarce. Almost all shrinkage cracks in this facies are crumpled (fig. 12) and are represented by a narrow light-gray filling of cracks formed in dark-gray laminae. Stylolites are particularly abundant but they have smaller amplitude than in the overlying buff unit—as many as 30 stylolites per inch have been recognized. Although pseudochannels with well-developed cores have not been noted in the black facies, low-amplitude flexures that produce a wavy stratification are common. The trend of these flexures is generally parallel to that of the pseudochannels in the gray facies, and they are probably related. Individual flexures die out above and below and affect only a few strata. They are distinctly different from any effect imposed by regional folding.

The outcrop characteristics of the black facies vary from place to place. In northern Gila County, outcrops near diabase commonly expose smooth bare surfaces that slope about 35° and are interrupted by narrow rounded ledges. The rock apparently exfoliates, and the spalled debris is locally washed from the slope by surface waters after rains. Where slope wash is negligible, the rock is rubble covered. Oxidation of pyrite and carbon extends little deeper than the spalled layers, probably because the rock has been indurated and partly recrystallized by the heat from the diabase. Outcrops away from diabase and most outcrops in south Gila County are generally hackly-surfaced cliffs and slopes. The exposed rock is flaggy from oxidation of pyrite and carbon in stylolites and stratification planes.

The black facies has a rather consistent thickness of about 100 feet in most of northern Gila County. There are, however, local abnormalities; for example, only 24 feet of the facies was measured at Canyon Creek and 62 feet at Walnut Creek. Only 44 feet was measured at Haigler Creek, but this is inferred to be near the margin of deposition. The thickest measured section of black facies in northern Gila County was 120 feet at Wilson Creek. In southern Gila County the measured sections range in thickness from 41(?) to 118 feet, with the exception of only 13(?) feet at Coolidge Dam, which is also near the inferred margin of deposition.

BUFF UNIT

The buff unit overlies the black facies with apparent conformity. It is distinguished from the black facies principally by change in color, coarsening of grain size, and topographic expression. The white quartzite marker, comprising one or more medium- to coarse-grained blocky orthoquartzite strata caps the unit.

The buff unit, which commonly forms a cliff, is typically a blocky feldspathic very fine grained sandstone with intercalated lenses of fine-grained orthoquartzite.

The feldspar-rich strata are silty to fine grained, whereas the orthoquartzite lenses are generally fine grained to medium grained. The stratification is ordinarily laminated to very thin bedded in the feldspathic sandstone, and cross-laminated in the orthoquartzite lenses. The coarser grained strata are planar cross-laminated; the finer grained strata have wispy or small-scale trough cross-lamination. Although largely blocky, the splitting property ranges from flaggy to massive.

The fresh rock in the buff unit is yellowish gray to grayish orange. Weathered exposures are generally coated with a film of limonite and range from light gray, through light brownish gray to pale red.

The composition of the buff unit is largely quartz, ranging from about 55 to 90 percent, and feldspar, ranging from about 5 to 40 percent (fig. 9). A little plagioclase and both microcline and orthoclase can be recognized in most thin sections. The remaining 5 percent or so of the rock is composed of clays, magnetite, ilmenite, limonite, hematite, and sparse pyrite, zircon, leucoxene, and calcite.

The rock is generally well indurated to quartzitic. Silica, as quartz overgrowths, is the most important cement, but iron oxides, clays, and feldspar overgrowths are significant cements in the feldspar-rich strata.

Stylolites in the buff unit are better developed than in any other unit of the upper member. Amplitudes of as much as half an inch are not uncommon. The stylolites are generally filled with pyrite in the fresh rock and at the surface they weather to a pale reddish-brown iron-stained band. Shrinkage cracks are common but not as prevalent as in the gray unit. Ripple marks are uncommon. Preconsolidation distortion structural features are not uncommon in the basal strata and can also occur in higher strata. Minor scour-and-fill structures are present locally.

The buff unit forms cliffs in most localities, but where it is strongly weathered or faulted, it breaks down to rugged ledges and steep rubble-covered slopes. It is generally the most resistant unit in the upper member.

The white quartzite marker bed, which caps the buff unit, was originally noted by Kaiser (1951) in the Red Bluff area, where it is particularly well developed. Elsewhere it is commonly thinner, less resistant to weathering, and more strongly iron-stained at the surface. Other orthoquartzite lenses with similar appearance that occur in some of the measured sections obscure correlation, and possibly one or more of these have been confused with the white quartzite marker in a few localities.

At Red Bluff the white quartzite marker is a nearly white, slabby to blocky, medium-grained orthoquartzite that forms a cliff about 14 feet high. It is laminated and cross-laminated, and it contains several coarse-grained lenses, particularly near the top. Elsewhere, strata correlated with the white quartzite marker at Red Bluff are 1 to 9 feet thick but are rarely so white or so pure. In general, the rock is a blocky to massive, yellowish to light-brownish-gray orthoquartzite. Weathered outcrops are ordinarily iron stained to pale red, moderate orange pink, or grayish orange. Where the buff unit stands as a cliff, the white quartzite marker forms a ledge at the top of the cliff. Elsewhere the marker is a resistant ledge in a steep slope.

Thickness of the buff unit ranges from 49 to 168 feet in measured sections where the white quartzite marker is present. Only 41 feet of

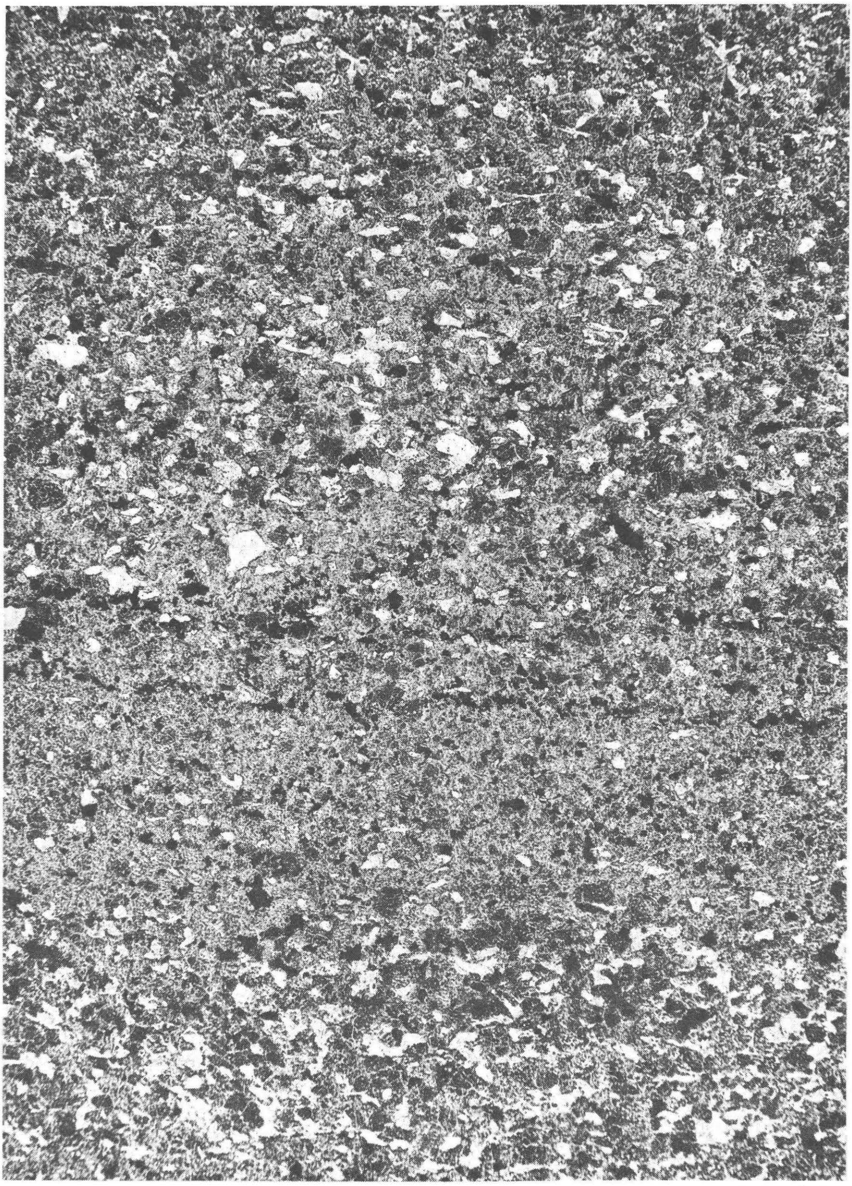

FIGURE 9.—Photomicrograph of arkosic arenaceous siltstone from the buff unit at Red Bluff. Clear grains are quartz; black grains are pyrite and magnetite. Remainder is an aggregate of altered feldspar and clay. Partly crossed nicols; × 29.

buff unit is present in the Pioneer section where the white quartzite marker was evidently removed prior to deposition of the Mescal. No consistent regional trend marks the thicknesses of the buff unit.

WHITE UNIT

The white unit is very thin in most places and probably would have been included with the buff unit had it not been for the area between Workman Creek and Red Bluff, where thicknesses of more than 100 feet were noted. The unit conformably overlies the buff unit.

Where best developed, the white unit is largely a flaggy, light-colored, evenly stratified siltstone. Grain size ranges from clay to very fine grained; graded strata are common. Stratification ranges from thinly laminated to very thin bedded. The strata are, for the most part, flat laminae of unusually consistent thickness both horizontally and vertically, but locally they are cross laminated.

Fresh rock ranges from dark to very light gray and grayish orange pink. Weathered surfaces are commonly lightly iron stained to very pale orange and pale yellowish brown.

Potassic feldspar and quartz are the dominant constituents and make up more than 90 percent of the rock. The potassic feldspar, identified by both optical and X-ray methods, is largely microcline. The remainder of the rock consists of plagioclase, clays, and minor pyrite and iron oxides. Clays locally predominate in some laminae and at the tops of some of the graded strata.

The rock is moderately to well indurated and is cemented by authigenic overgrowths on the quartz and feldspar and by clay minerals. Generally, the dominant constituent in the rock provides the cementation. Sedimentary structural features such as shrinkage cracks, ripple marks, and pseudochannels are either very scarce or absent.

The thickness of the white unit varies considerably in Gila County and does so fairly abruptly. For example, at the point where the Workman Creek section was measured, 124 feet of white unit is present; but only 1 mile to the northeast, on the north side of Workman Creek, less than 20 feet of white unit is present. About 1.5 miles to the south, near the Parker Creek Experiment Station, approximately 70 feet of the white unit is present. With the exception of the Copper Mountain and Haigler Creek sections, which have 35 and 31 feet of white unit respectively, all the other sections contain 20 feet or less. It is missing in several sections, probably because of pre-Mescal erosion.

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CONTACT WITH MESCAL LIMESTONE

The Mescal Limestone, in most places, was deposited on a broad, nearly conformable erosion surface cut in the white unit. Locally, the white unit was removed completely.

The lowest unit of the Mescal, which might be termed a microconglomerate, is a rock consisting of medium and coarse quartz and feldspar grains in a silty to clay-sized matrix. The larger quartz grains (fig. 10) almost invariably have wavy extinction or are composed of a mosaic of finer, elongate, sutured quartz grains, suggesting a source from foliated metamorphic rocks. The feldspar is largely microcline. The matrix consists of finer quartz, feldspar, clay minerals, and, locally, carbonate minerals (A. F. Shride, oral communication). Chlorite and iron oxide minerals are common.

Fragments of the upper member of the Dripping Spring are locally enclosed in the lower few inches of this rock, and fragments of cherty Mescal are common a few feet higher. The contact between the Dripping Spring and Mescal is easily recognized in most places by the abrupt change from well-sorted to poorly sorted material.

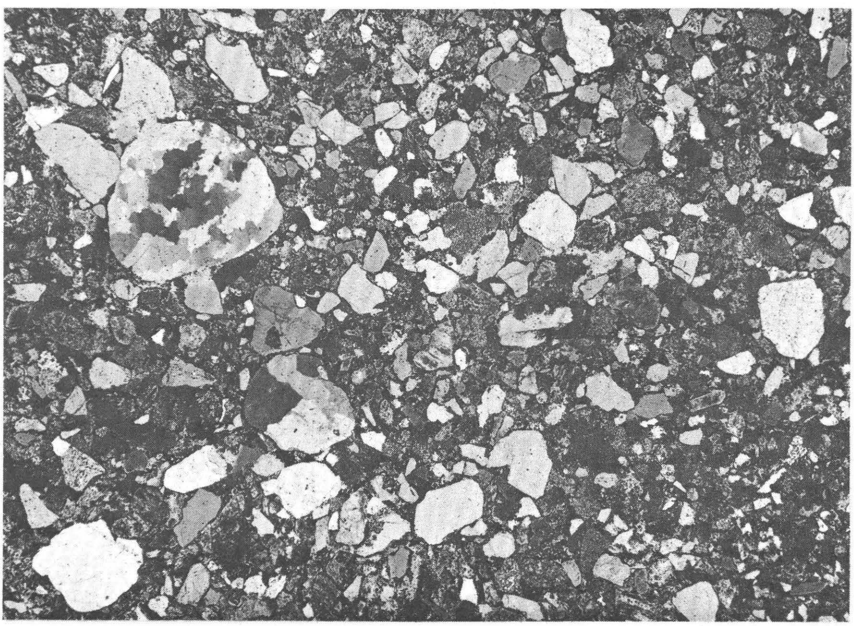


FIGURE 10.—Photomicrograph of poorly sorted sandstone at the base of the Mescal Limestone, Bull Canyon section. Clear grains are quartz; cloudy grains are feldspar; matrix is clay minerals. Note the large quartz grains composed of sutured quartz and probably derived from a metamorphic rock. Partly crossed nicols; × 18.3.

SEDIMENTARY AND SECONDARY STRUCTURES

CROSS-STRATIFICATION

Two main varieties of cross-stratification have been recognized in the upper member: a typical planar cross-stratification, and a variety of trough cross-stratification herein termed wispy cross-lamination.

Most fine- to coarse-grained sandstone and orthoquartzite strata are planar cross-stratified. Individual cross-laminae are commonly graded in size and composition so that they are finer grained and more feldspathic upward. Cross-stratification is ordinarily obscure in the orthoquartzites because of the more consistent composition and grain size.

The wispy cross-lamination affects largely the very fine grained and silty strata in the buff unit and, to some extent, in the gray unit. It is a variety of trough cross-lamination in which individual sets are less than 2 inches thick and the cross-laminae are relatively broad and dip at a very low angle. The boundaries of sets are vague and confused by erosion and deposition of succeeding sets. The appearance indicates that they were caused by small shallow anastomosing rills cutting and depositing at the surface of very poorly consolidated water-saturated muds and sands.

RIPPLE MARKS

Ripple marks are present in all but the white unit of the upper member. In a general way they are most common in the red unit and decrease upward. The buff unit, however, has more ripple marks than the black facies. Most of the ripple marks are of the current or oscillation type, consisting of subparallel, nearly symmetrical ridges and furrows with a wave length of 1 to 3 inches.

Another type of ripple mark, referred to as cusp ripple marks, consists of irregularly but closely spaced cusplike depressions about 4 to 12 inches across. These also occur in the upper part of the middle member.

SHRINKAGE CRACKS

Shrinkage cracks are most common in the gray unit but also occur in the red and buff units. The cracks are generally in silty and argillaceous strata and are filled with very fine grained sandstone.

The filled cracks generally make a polygonal pattern on stratification planes (fig. 11), but randomly oriented or subparallel patterns of incomplete (Shrock, 1948) cracks are not uncommon. The latter two may be confused with fucoidlike markings or striae caused by differential movement between strata.

In cross section the crack filling in some places has been contorted by differential compaction (fig. 12). They are termed crumpled shrinkage cracks (see also Bradley, 1930) and result where the less

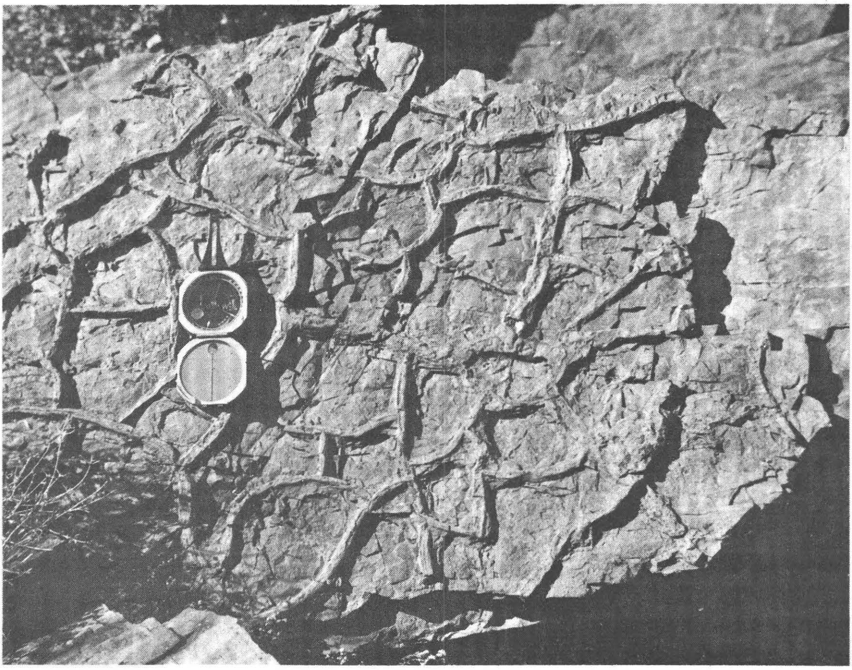


FIGURE 11.—Shrinkage cracks in the gray facies at Red Bluff. Siltstone in which the cracks formed has been partly eroded away, leaving the very fine grained sandstone filling in relief.

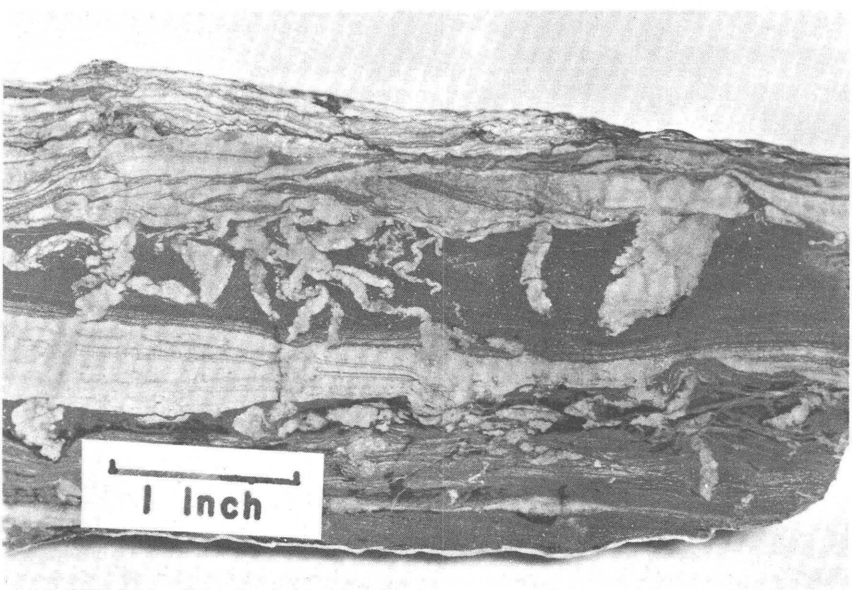


FIGURE 12.—Cross section of crumpled shrinkage cracks in the black facies at Walnut Creek. The distorted filling of very fine grained sandstone cuts both light and dark siltstone strata. Note that the stylolite near the top of the specimen splits into four separate stylolites toward the left.

compactible filling forms irregular, commonly wavy shapes in the more compactible siltstone laminae. These are particularly striking where the cracks have formed in dark-gray carbon-rich siltstones and the filling is a very light gray sandstone. They are most prevalent in the lowest 10 or 20 feet of the black facies.

PSEUDOCHANNELS

Pseudochannels are subparallel features consisting of a central lens or core of undeformed sandstone strata, roughly U-shaped in cross section and cigar-shaped in plan, imbedded in downwarped finer grained material (fig. 13, 14). The cores range in size from several inches long and 1 inch deep to more than 20 feet long and as much as 3 feet deep; widths are commonly, though not invariably, slightly greater than depths. The long axes of the cores are remarkably parallel throughout any given exposure. Trends are generally N. 5° E. to N. 25° E. in the northern part of Gila County and are more northeasterly in the southern part of the county. No relation was found between pseudochannels and the uranium deposits even though their trends are notably similar.

The best exposures of pseudochannels are at the Wilson Creek, Walnut Creek, Canyon Creek, and Gerald Wash section localities. The features are restricted to the gray unit of the upper member and nearly all of the well-developed pseudochannels are in the gray facies and the gray sandstone. In the black facies and the upper part of the gray facies are gently wavy or warped strata in which the "fold" axes are subparallel to the pseudochannels. Although no cores are present, these features may be related to the pseudochannels.

The cores of pseudochannels are commonly composed of thin laminae of very fine grained or silty feldspathic and arkosic sandstone (fig. 14*B*). The laminae are generally parallel to the surrounding stratification but may dip slightly to as much as 20° from one side of the core to the other. No contorted laminae have been seen. In cross section, the cores are principally convex downward but may also be slightly convex upward. The convexity is commonly asymmetric but even closely spaced cores at the same stratigraphic horizon may have opposing symmetry.

The cores are enclosed in very thinly stratified siltstone and claystone. Many of the enclosing laminae are thinned and truncated against the sides of the cores as well as downwarped around the bottom of the cores. The interface between the cores and the enclosing laminae commonly is polished and marked by minute subparallel ridges, probably healed tension cracks or slickensides. The ridges ordinarily are nearly normal to the axes of the cores but may depart as much as 30°

A cross section through a stratigraphic interval that contains pseudochannels shows the complex arrangement of the features (fig. 15). Cores in a wide range of sizes and shapes occur at many horizons. The tops of interconnected as well as individual cores may be at a single horizon, but cores also occur with their tops at the same stratigraphic level as the middle of adjacent cores. Although many cores are interconnected by strata of similar material, others are not connected. In these, the cores may end abruptly, or lenses of the core material may extend several inches or feet on one or both sides of the core before terminating or feathering out.

ORIGIN

The origin of the pseudochannels cannot be stated with certainty. Raup suggests, however, that they may be "roots" of tidal current ripple marks.

The absence of distorted laminae in the cores rules out an origin by intraformational disturbances or by flowage due to unequal loading both of which are characterized by features composed of highly contorted laminae. Even more restrictive is the widespread consistent parallelism of the pseudochannels. Parallel channels have been noted by E. D. McKee (oral communication, 1957) at the mouth of a bay that filled and drained with each tide. The mouth of the bay was rather restricted, however, and the size of the bay was considerably less than the area in which alined pseudochannels have been observed in Gila County.

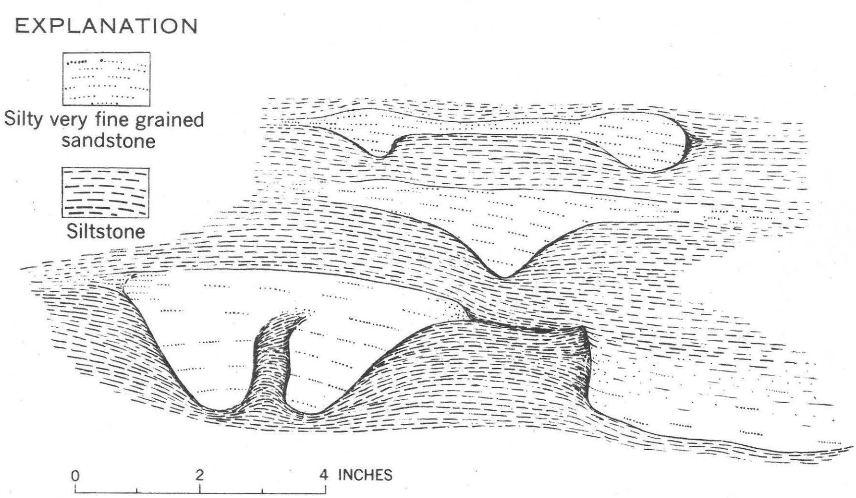


FIGURE 13.—Cross section through pseudochannels.

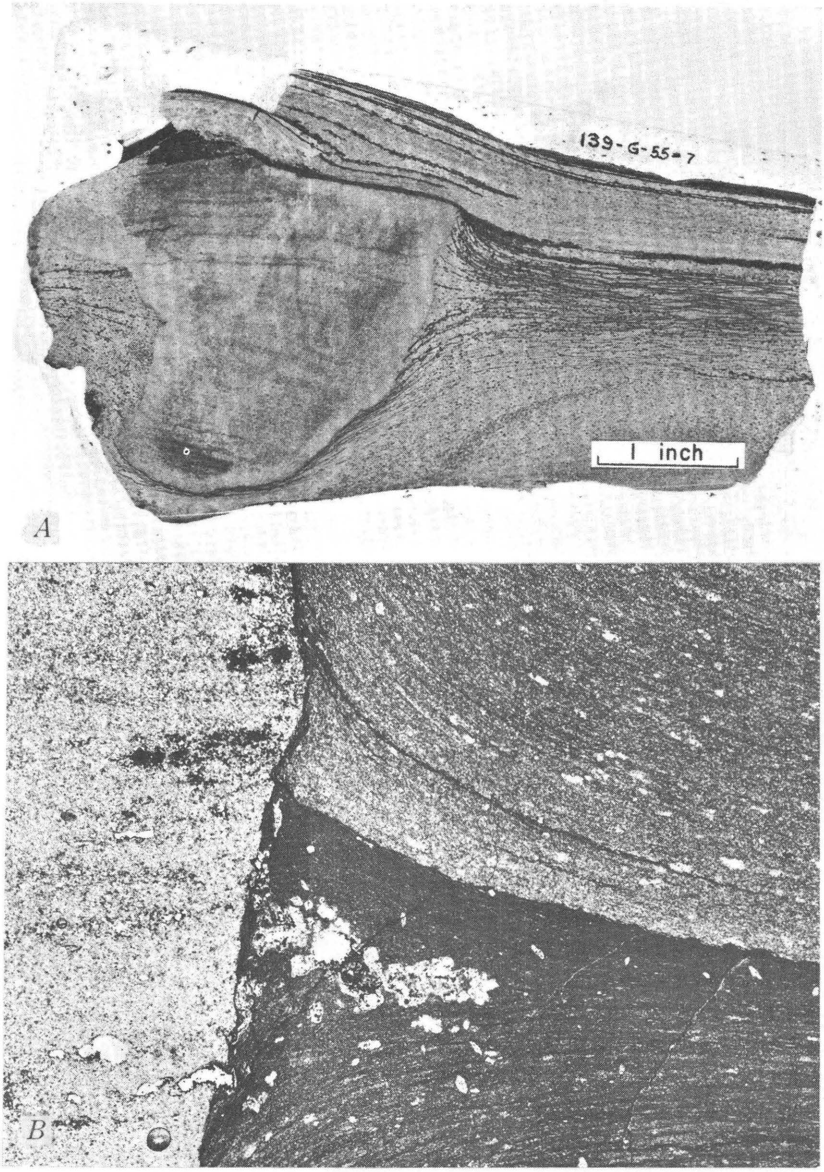


FIGURE 14.—*A*, Cross section of a pseudochannel. Stratification is marked by limonite in the weathered rock. Siltstone strata at the edge of the core are warped and truncated in contrast to the undisturbed strata in the core. Specimen is enclosed in plaster of paris. *B*, Photomicrograph of the contact between a pseudochannel core and warped truncated siltstone. Relations are similar to those on the right side of the core illustrated in *A*. Plane-polarized light; X 6.

Tidal current ripple marks would be elongate and parallel. If such ripple marks developed in a fine-grained sand over hydroplastic mud, the increased load under the crest of a ripple mark might cause some of the sand to be pressed into the mud, without appreciable distortion of the sand laminae. Some laminae in the mud would be thinned and truncated by the downward movement of the "root." The rhythmic ebb and flow on a tidal flat would account for the removal of nearly all the sand execept where preserved as cores. As new strata were deposited above, differential compaction between the sand cores and the clay-rich enclosing laminae would further thin and truncate the enclosing laminae and polish the interfaces between these laminae and the cores.

FUCOIDLIKE MARKINGS

Certain randomly oriented impressions on bedding plane surfaces have been called fucoidlike marks (fig. 16). They occur on the surfaces of arenaceous siltstone and very fine grained sandstone strata of the upper member. Mostly they have been noted in the lower parts of the member, particularly the gray facies.

FIGURE 15.—Pseudochannels in an outcrop of the gray facies at Walnut Creek. The large pseudochannel seen in cross section in the center of the photograph is surrounded by a multitude of smaller pseudochannels.

The fucoidlike markings typically form a profusion of shallow elongate impressions commonly about 0.5 inch long, 0.2 inch across, and 0.05 inch deep that become more narrow and shallow toward the ends. Some have angular outlines; others have somewhat vermicular and more nondescript forms. They should not be confused with poorly developed shrinkage cracks which, on careful examination, show a more regular pattern.

Whatever caused the markings must have had sufficient rigidity to produce an impression on the stratification surfaces. They may have been caused by a primitive sea weed or, perhaps, by some type of crystal growth.

Gastil (1953) described "bedding casts" in the upper member. The fucoidlike marks described above are probably one type of "bedding cast" that he observed.

STYLOLITES

Stylolites are extremely common in the upper member, mainly in very fine grained sandstone and siltstone facies. In the field they are most evident in the buff unit because they have greater amplitude

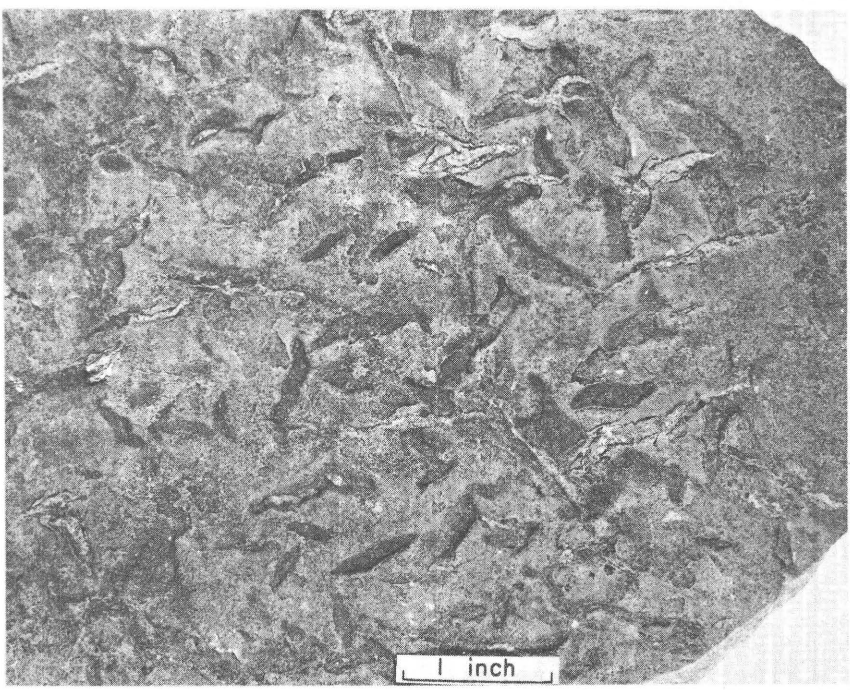


FIGURE 16.—Fucoidlike marks on a stratification surface of siltstone from the gray facies at Copper Mountain. A few of the molds are filled with siltstone of the overlying stratum.

there than elsewhere in the upper member, and because they are iron-stained on weathered surfaces. Stylolites with amplitudes as much as 2 cm are present (fig. 17*A*, *B*). In the black facies the stylolites generally have amplitudes of 2 mm or less but may be very abundant. In 1 specimen from the Bull Canyon area there were 30 stylolites in a stratigraphic thickness of 1 inch. Below the black facies stylolites are less prominent, and no stylolites were seen in the middle member.

Although stylolites were examined in a dozen thin sections from several localities, there was no evidence that any stylolites were cut by later joints or veins. The filling in stylolites appears to cut across the filling of veinlets, where both features occur in the same specimen. In specimens that contain both crumpled shrinkage cracks and stylolites transverse to the stratification, the stylolites show no evidence of distortion. Crumpled shrinkage cracks in metamorphosed rocks near diabase have locally been preserved as relict features, but stylolites seemingly are missing, suggesting that stylolites were formed after metamorphism.

All the observed stylolites in fresh rock are filled in part with pyrite. Carbon is also an abundant constituent in stylolites in the gray unit. The carbon is generally most prevalent near the walls, and pyrite forms grains and aggregates in the centers or completely fills the stylolites. No refractory minerals were noted at the crests of stylolites.

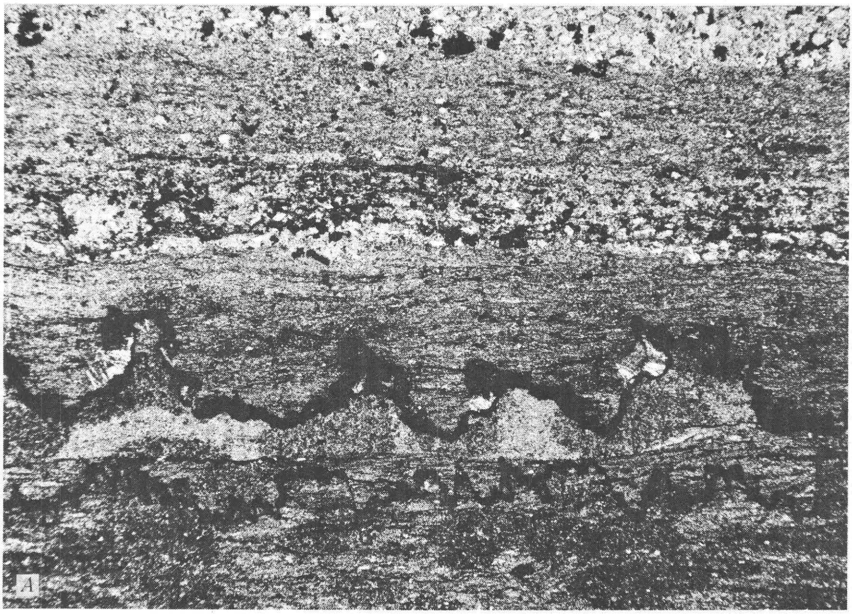
Where oxidized, the stylolites may be filled with an iron-stained clay or a chloritelike mineral. Fibrous unidentified minerals parallel to the "limbs" of the stylolites are not uncommon.

At the surface, oxidation of iron locally produces red hematitic bands bordering the stylolites, particularly in the buff unit. Oxidation of iron and carbon may aid the rock in splitting near the surface and produce a platy splitting property not seen in the fresh rock.

The thickness of measured sections of the upper member may not be representative of the original thickness of the member because of solution along stylolitic bands. No approximation can be made as to the thinning caused by stylolitic solution, but sections where the stylolites are particularly abundant or have large amplitude must be considerably thinner than at the time of deposition.

METAMORPHIC PHENOMENA

Thermal and hydrothermal metamorphism of the Dripping Spring near diabase intrusives is common in Gila County, particularly in the Sierra Ancha region. Two general types of metamorphic alteration have been observed: the highest grade of metamorphism has resulted in hornfels and closely related rocks, and a lower grade but more pervasive metamorphism has resulted in a "spotted rock."



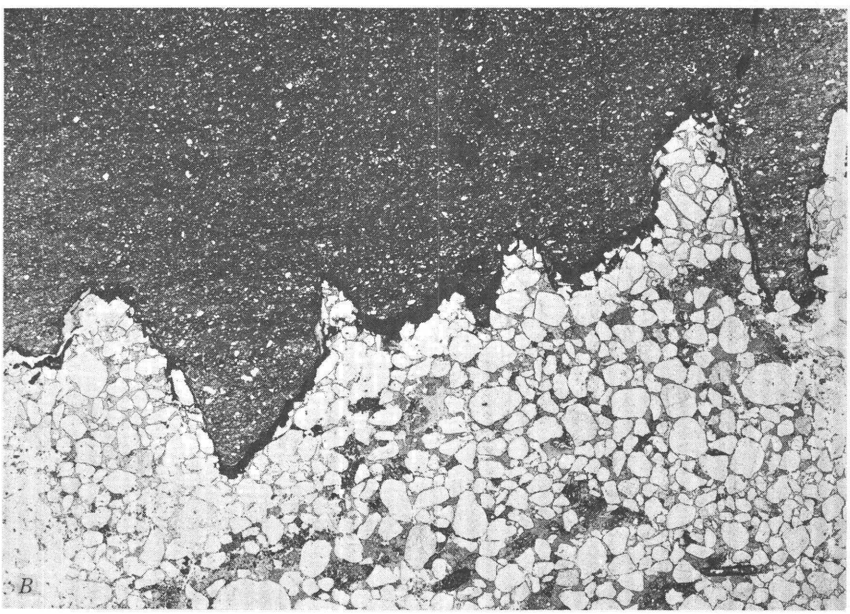


FIGURE 17.—Photomicrographs of stylolites. *A*, in the black facies at the Red Bluff section. Stylolites are filled with carbon and pyrite. Plane-polarized light; × 18.3. *B*, between orthoquartzite and siltstone in the lower part of the black facies at Bull Canyon. Siltstone is carbon rich; stylolite is filled with pyrite; quartz grains in orthoquartzite are cemented by quartz overgrowths and calcite. Plane-polarized light; × 6.

HORNFELS

Hornfels has been locally produced adjacent to diabase bodies by contact thermal metamorphism of potassium-rich siltstones. Rocks of the gray unit are apparently the most susceptible. In the Workman Creek area hornfels has been formed just above a diabase sill over an area of several square miles.

Strong thermal metamorphism near a diabase body results in recrystallization of the potassium-rich siltstones for as much as 100 feet from the contact. The initial product is a hornfels composed of K-feldspar, quartz, sphene, augite, biotite, and sulfide minerals. Optical and X-ray diffractometer studies indicate that the original monoclinic K-feldspar is inverted or recrystallized mainly to microcline with lesser amounts of orthoclase. The grain size is similar to that of the original siltstone. Somewhat stronger metamorphism near the contact results in recrystallization of the hornfels to a coarser grained rock of the same general composition but with less augite and biotite. Here the K-feldspar is ordinarily orthoclase but there can be various amounts of associated microcline and (or) sanidine. This recrystallized hornfels forms small scattered orbs in the finer matrix, layers of coarse-grained material in lit-par-lit relation to the finer hornfels, or, ultimately, a completely homogeneous coarse-grained recrystallized rock.

SPOTTED ROCK

Spotted rock contains a multitude of small disseminated spheroids of secondary minerals. Although spotted rock is most abundant in the basal strata of the buff unit, it may be found almost anywhere in the upper member. It has been noted only near diabase bodies but not so near, in general, as hornfels. The spheroids range from less than 1 mm to as much as 4 mm in diameter. On a broken surface they may appear either as light spots on a dark background or as dark spots on a light background. There seem to be several types of various mineral compositions.

In some rocks the spots are a dark aggregate of nontronitic clays and feldspar in discrete spheroids. In others they are light-colored sericite-rich blebs in an otherwise cloudy, clay-rich matrix; in these, the grain size is approximately the same as the surrounding material except where the sericite (muscovite) is particularly well developed. In still another type, the light spots seem to be coarser recrystallized minerals, particularly feldspar.

RADIOACTIVITY

Radioactivity of the upper member is abnormally strong. Magleby and Mead (1955), who measured the radioactivity with an airborne scintillation meter calibrated in microamperes, found that the normal background radioactivity of the upper member ranged from 375 to 475 microamperes as contrasted with 75 microamperes over water and 375 to 500 microamperes over granite. Ground surveys that we made with a portable scintillation meter at the time the sections were measured indicate that normal background radioactivity of the upper member ranges from about 0.02 to 0.07 mr per hr. This contrasts with 0.008 mr per hr in diabase and 0.015 to 0.04 mr per hr in the middle member.

Some of the abnormally high radioactivity noted in the upper member in the field is caused by proximity of the measured sections to uranium deposits. The radioactivity of specimens from the black facies, however, cannot be entirely accounted for by the uranium content. Chemical analyses have shown that these rocks contain enough potassium to account for the excess radioactivity (table 6). A rock that contains 2 percent potassium contains enough of the radioactive K^{40} isotope to be equivalent to 0.001 percent uranium (John N. Rosholt, oral communication, 1955).

TABLE 6.—*Radioactivity of the black facies of the upper member, Dripping Spring Quartzite*

[Analyst, I. G. Frost]

Field No.	Location	Equivalent uranium percent (eU)	Uranium percent (U)	Thorium percent (Th)	Potassium percent (K)	Radioactivity due to K in terms of eU percent eU (K)
99G54	Diamond drill core, Regal asbestos mine	0.010	<0.002	0.001	8.7	~0.0043
128G54	Workman Creek area	.018	.017	--------	12.1	.0060
141G54	Wilson Creek area	.033	.029	--------	10.1	.0050
103G55	Bull Canyon area	.010	.005	--------	9.6	.0048
104G55	Snakebit area	.008	<.002	--------	10.5	~.0052
106G55	Red Bluff area	.006	<.002	.001	10.1	~.0050
Average		0.014	0.009	0.001	10.2	0.005

NOTE.—The radioactivity attributable to thorium is negligible. Hence if the uranium is in equilibrium with its daughter products, the following equation is true: eU(K)+U=eU. Discrepancies in this equation are probably due to lack of equilibrium between uranium and its daughter products.

SOURCE OF THE CLASTIC MATERIAL

Considerable data pertaining to source areas were accumulated during measurement of the stratigraphic sections. These observations fall into two general groups: (a) character of the clastic material, which includes grain size, roundness, and composition; and (b) primary sedimentary features, such as thickness, cross-stratification, imbrication, paleochannels, and ripple marks.

Field estimates of such parameters as grain size, roundness, and composition are, perhaps, more nearly an impression gained by the observer than they are true quantitative measurements, but they are useful for determining general trends.

The source of the clastic material in the Dripping Spring has been discussed only briefly by earlier workers whose data were largely accumulated from small areas and apply principally to the stones in the Barnes Conglomerate Member. There has been a tendency to disregard most sedimentary parameters in favor of comparing the composition of stones in the Barnes with composition of pre-Apache rocks that might have provided a source. This method alone may be unreliable, as the source rocks may have been completely removed by erosion or may now be covered by later rocks.

GRAIN SIZE

Regional variations in the grain size of the Dripping Spring were compared by calculating a numerical index for the estimated average grain size of the members at each measured section (table 7). Comparison of these indices points out local variations in the Barnes that may be significant, although there seem to be no consistent regional variations in the other members.

The grain size indices for the Barnes Conglomerate Member are smallest at Copper Mountain, and are usually small at Roosevelt and Coolidge Dams, reflecting the tendency of the Barnes to wedge out to the northwest and southeast in Gila County. Ransome (1916, p. 150) and Gastil (1953) also observed that the average size and abundance of stones in the Barnes seem to decrease northward in the county.

The grain size indices of the middle member are apparently lowest in the Red Bluff-Bull Canyon area, but the differences are probably too small to be of any importance. Study of the grain-size variations in individual strata of the middle member might lead to more significant results, but it was not attempted because of the lack of reliability in correlation.

Sections of the upper member having the finest grain size apparently lie to the southeast. Whether these results are significant is open to question, as a part of the buff unit is missing in each of these sections

TABLE 7.—*Indices*[1] *of estimated average grain size in the Dripping Spring Quartzite*

[N.M., Not measured because section is missing, covered, faulted or intruded by diabase]

Locality	Barnes Conglomerate Member	Middle member	Upper member
Barnes Peak	2. 70	1. 46	0. 924
Bull Canyon	2. 50	1. 28	. 985
Canyon Creek	3. 06	1. 53	. 928
Cherry Creek	(N.M.)	(N.M.)	. 892
Coolidge Dam	2. 32	1. 48	. 720
Copper Mountain	2. 00	1. 40	. 808
DeVore Wash	2. 70	1. 42	(N.M.)
Gerald Wash	3. 26	(N.M.)	. 855
Haigler Creek	(N.M.)	(N.M.)	. 824
Natanes	2. 93	1. 49	. 730
Pioneer	3. 39	1. 44	. 699
Potts Canyon	3. 20	1. 43	. 867
Red Bluff	2. 87	1. 28	. 888
Roosevelt Dam	2. 34	1. 51	. 805
Snakebit	(N.M.)	(N.M.)	. 805
Walnut Creek	(N.M.)	(N.M.)	. 962
Wilson Creek	(N.M.)	(N.M.)	. 924
Workman Creek	(N.M.)	(N.M.)	. 800

[1] Grain size indices were calculated by the following method:

$$I=\frac{T_1 \log i_1 + T_2 \log i_2 + T_3 \log i_3 + \ldots}{T_1+T_2+T_3+\ldots}$$

where

I=grain size index for the member or unit
T=thickness in feet of measured stratigraphic interval
i=estimated average grain size (in millimeters $\times 10^2$) of interval
$T_1+T_2+T_3 \ldots$ =total thickness of member or unit
I stones$\geq$2.30; I sand=.796–2.30; I silt and clay$\leq$.796.

and a normal thickness of the generally coarser grained buff unit would undoubtedly increase the average grain size. Lateral grain-size variations in the various units of the upper member are, therefore, believed to provide no consistent pattern, but as the available data are based largely on distinction in the field between siltstone and very fine grained sandstone, there may be differences that are not megascopically distinguishable.

Grain-size variations in the Dripping Spring in Gila County give no reliable evidence concerning the source of the clastics. There seems to be no consistent increase in grain size toward any part of the inferred margin of the Apache embayment, suggesting either that these were not areas of provenance, or that the clastics were evenly distributed regardless of nearness to source. The fact that rounded stones in the Barnes appear to be finer grained to the northwest and southeast seems to strengthen the evidence that these were not significant source areas.

ROUNDNESS

Differences in roundness of the clastic grains in the Dripping Spring were determined in the field only for the Barnes. Microscopic examination of the rocks in both the middle and upper members disclosed that sandstone grains are generally well rounded to subrounded, and that silts are subangular. Feldspar grains are almost invariably more poorly rounded than adjacent quartz grains.

Data based on the roundness of stones in the Barnes at presently known exposures are inadequate to indicate a source direction. The reddish jasper is commonly subrounded to subangular, but quartzite and quartz stones in almost every exposure of Barnes Conglomerate Member are subrounded to well rounded. Exceptions to this widespread uniform rounding occur in northern Gila County near the Diamond Butte quadrangle. These stones, although locally incorporated in the Barnes Conglomerate Member, are probably of local origin related to talus mantles on partly buried highlands (Gastil, 1953). At Copper Mountain, for example, the Barnes contains a few subangular granite and feldspar stones as well as the more typical rounded quartz and quartzite stones. The likelihood that these were derived from the same source is considered to be remote.

COMPOSITION

Most attempts to establish a source area for the Dripping Spring Quartzite have in the past dealt with the similarity between clastics in the Barnes and pre-Apache rocks exposed in western and northern Gila County, suggesting that the source area was to the north and west.

At Roosevelt Dam, Wilson (1939, p. 1139) noted that the quartzite stones in the Barnes are lithologically identical to the Mazatzal Quartzite. He also noted, however, other quartzite units of similar appearance in the lower Precambrian sequence and observed that red jasper, which is so common in the Barnes, is present in all the conglomerates of early Precambrian age.

Source areas for the well-rounded stones in the Barnes cannot be reliably established on the basis of composition until considerably more data are available. Although the only known outcrops of quartzites of early Precambrian age are north and northwest of the Sierra Ancha, it would be presumptuous to limit the possible source area to the present outcrop area.

Presumably the quartzite stones in the Barnes were derived from quartzites of early Precambrian age, and the white quartz stones were derived from quartz veins and pegmatites associated with granite and metamorphic rocks of pre-Apache age. Nearly all the stones in the Barnes throughout its outcrop area are composed of quartzite and quartz. Although the quartzite-quartz ratio is different in the various sections, there seems to be no consistent lateral variation that would be suggestive of a source direction. Small pebbles and granules of red jasper also occur in nearly every known exposure of Barnes. Their abundance is little if any greater in northern Gila County than in the Vekol or Little Dragoon Mountains to the south.

The regional uniformity of the stones in the Barnes apparently precludes determination of the source areas by lateral variation in the composition. Locally, however, subangular feldspar, granite, and other stones are incorporated with the normal rounded stones of the Barnes and these are, no doubt, of local derivation.

The ratio between quartz and feldspar content of the Dripping Spring at the different sections might provide a means of deducing the direction of source, but an initial assumption must be made either that the ratio increases or that it decreases away from the source. Under most present-day conditions the feldspar would likely decrease away from the source because of the destructive effects of chemical weathering and transportation. If, on the other hand, conditions were such that weathering was largely mechanical, relatively unaltered feldspar might be reduced to a size somewhat smaller than associated quartz and would be transported farther from the source area. The latter conditions seem more nearly to account for the grain size and composition of the middle member, which consists in large part of relatively fresh feldspar grains slightly smaller than associated quartz grains. This is especially true of graded strata that are commonly more quartzose near the base and more feldspar rich in the finer strata near the top. In addition, strata that are medium grained or coarser generally contain a larger percentage of quartz than do the finer grained rocks.

To determine lateral variations in feldspar content in the middle member of the Dripping Spring, the ratio of quartz to feldspar was calculated from field estimates at each locality. The results indicate a decrease of feldspar content toward the east. At Potts Canyon and Roosevelt Dam, the estimated average feldspar content in the middle member is about 40 percent. At Coolidge Dam, Natanes, and Canyon Creek the feldspar content ranges from 20 to 25 percent. In the intervening sections about 30 percent feldspar seems to be typical. Thus, it would seem most likely that, if the greater feldspar contents are farthest from the source, the source of the middle member was to the east. We believe, however, that the middle member represents thoroughly reworked unconsolidated arkosic sands and by this reasoning the ultimate source is obscure.

In both the upper and middle members, the presence of quartz grains with wavy extinction as well as grains composed of finer sutured quartz grains strongly suggests that at least some of the clastic material was derived from a metamorphic terrane. Although

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this does not point to a source direction, it indicates that a terrane composed solely of igneous rocks was inadequate to supply the detritus composing the Barnes, middle, and upper members.

In the light of available data, the minor constituents apparently offer no clue to the source of the clastic material. Gastil (1953) studied heavy mineral fractions from Apache strata in the eastern half of the Diamond Butte quadrangle and reported that there is a distinct lack of foreign detritus in the Dripping Spring. For example, he noted no grains of high- or intermediate-grade metamorphic origin. He concluded that the distribution of basement rock types in southeastern Arizona are too poorly known to draw conclusions about source areas from the detrital grains.

THICKNESS

Lateral variations in the thickness of the Dripping Spring as a whole tend more to define the size and shape of the basin of deposition than to define source areas. Of the individual units within the formation, however, two show consistent lateral variations in thickness that may indicate source areas, assuming that the units are thicker toward the source, and wedge out away from the source. The Barnes Conglomerate Member and the red unit of the upper member apparently lens out to the north and northwest. The red unit in particular has a wedge shape; it is as much as 83 feet thick at the Pioneer section and is missing at the Copper Mountain, Haigler Creek, and Wilson Creek sections. The Barnes Conglomerate Member has essentially the same thicknesses throughout most of Gila County, but it wedges out to the north in the area of the Diamond Butte quadrangle and to the southeast near Coolidge Dam. There is also evidence of at least a local pinchout of the Barnes to the southwest in the Vekol Mountains (Carpenter, 1948).

CROSS-STRATIFICATION

Cross-stratified rocks in the Dripping Spring Quartzite are primarily in the middle member, but intercalated sandstone beds in the Barnes and sand-sized units in the upper member are locally cross-stratified. At the Potts Canyon section, 169 apparent dips were measured in the middle member, and at the Haigler Creek section a significant number of dips were measured both in cross-stratified sandstone beds in the conglomerate underlying the upper member of the Dripping Spring and in the buff unit. These were corrected for the dip of the host units. The most prominent cluster of dips at Potts Canyon is to the northeast, suggesting transport in a northeasterly direction. Plots of cross-strata dips in the Haigler Creek section are consistently in the northeast quadrant. The resultant dip direction is N. 60° E. A marked tendency for cross-strata to dip to the northwest in the middle member was noted at Copper Mountain, although no statistical analysis was made.

Many other observations of the dip of cross-strata were made by us throughout Gila County, but the number at any given locality was too few to be analyzed statistically. Although the measured dips were in all quadrants, dips in the northeast and northwest quadrants seem to be more common. Thus the general impression is one of northward transport.

IMBRICATION

The conglomerates in the Barnes and at the base of the middle member of the Dripping Spring are the only units in which imbricated stones can be observed. Imbrication in these units has rarely been noted, however, even though the conglomerates are rudely stratified in several exposures. Inasmuch as most of the stones are more spheroidal than discoidal or bladed, the chances for imbrication were materially reduced.

Measurably imbricated stones were observed at two places in the Barnes. In addition, Gastil (1953) noted one example of imbricated stones in the southwest corner of the McFadden Peak quadrangle, and Cooper and Silver (in press) measured imbrication structures in the Barnes exposed in the Little Dragoon Mountains. Gastil's observation indicated strongest current movement to the west; Cooper's observations indicated strongest current movement to the southeast. Our measurements indicated strongest current movement N. 20° W. at the Pioneer section and to the south at the Natanes section.

PALEOCHANNELS

Well-defined paleochannels are scarce in and at the base of the Dripping Spring Quartzite. Gastil (1953) noted conglomerate deposited in paleochannels cut into the top of the Pioneer Formation in the eastern half of the Diamond Butte quadrangle, but no data on the trends of these paleochannels are presented. We observed small paleochannels filled with Barnes at the Pioneer, Red Bluff, Natanes, and Roosevelt Dam sections, and a possible paleochannel at the same stratigraphic horizon about 10 miles southeast of Globe. At least three paleochannels were observed within the Dripping Spring.

Broad, nearly conformable channels or depressions in the surface of deposition of the Barnes may exist, but we examined few places where the contact was well exposed for more than a few hundred feet. The only paleochannels observed within the Dripping Spring as well as at the Pioneer-Barnes contact are characterized by relatively abrupt unconformity.

The paleochannels beneath the Barnes at the Pioneer section are small, the largest observed being about 2 feet deep. They are cut into red shaly strata at the top of the Pioneer Formation and are filled largely with pebble-sized stones. Some of the scours form an arborescent pattern branching to the southeast. If these channels were scoured by the same agent that transported the Barnes, northwestward transport would be indicated. The channels at the Red Bluff, Natanes, and Roosevelt Dam sections range from 1 to 4 feet deep. No trends were measurable.

The paleochannel (?) about 10 miles southeast of Globe is also cut into shaly strata at the top of the Pioneer Formation and is filled with Barnes Conglomerate Member. The depth of the channel is estimated to be about 6 feet, but only one side was observed because of cover and the width could not be determined. The trend also could not be determined accurately but it may be northwestward. Very poor exposure hindered study of the unconformity, and possibly the angular discordance may be due to local uplift and planation of the Pioneer rather than to channeling prior to deposition of the Barnes.

Three paleochannels were observed in the gray sandstone facies of the upper member. The paleochannel at Blevins Canyon trends northward; the trend at Walnut Creek is northwestward. The trend was not determined for the Cherry Creek paleochannel.

If pseudochannels reflect rill channeling or a similar feature, their trends may reflect direction of current flow. They tend to be alined in a north-northeasterly direction in central and northern Gila County and in a more northeasterly direction in the southwestern part of the county. Until positive identification of the features is made, however, their relation to the direction of sediment transport and to source areas is unknown.

RIPPLE MARKS

Ripple marks are sparse in the middle member but are more common in the finer grained strata of the upper member. Cusplike current ripple marks are too irregular in form to indicate the directions of flow. The more regular marks observed are subparallel current and oscillation ripple marks. These features are so poorly exposed that it was impossible to make a significant number of observations at any given horizon. Trends of ripple marks only a few feet apart stratigraphically were found to differ by as much as 90°. A compilation of all the data on the trends of ripple marks observed in Gila County indicates random distribution. The same is true of the few observations of rill-mark trends.

CONCLUSIONS

Conclusions drawn from the foregoing data are, at best, tentative. Most of the data refer to the directions of current movement and these data alone do not indicate source areas, particularly under marine conditions. Probably the most reliable data are those on grain size, thickness, and some phases of composition. As noted, however, interpretation of source direction from some of these data is first dependent on interpretation or assumptions regarding depositional processes.

Summation of all the data suggests that much of the current movement was northward, and that the source of much of the detrital material was in the south. Conflicting evidence, however, is prevalent enough to cast doubt on the conclusion. We tend to believe that most of the material that makes up the Dripping Spring in Gila County was derived from a southern source, but we acknowledge the indisputable evidence that some material was derived locally in the northern Sierra Ancha and also recognize the possibility of several source areas along the margins of the basin.

SHAPE OF THE BASIN OF DEPOSITION

The shape of the basin in which the Dripping Spring was deposited is best determined from isopach maps based on the thickness of various measured sections. Using data from the 17 sections we measured, and selected data (table 8) from Ross (1925a, b), Darton (1925), Bejnar (1950), and Gastil (1953), we prepared isopach maps of the total Dripping Spring (fig. 18), the middle member (fig. 19), the upper member (fig. 20), and the red and gray units of the upper member (fig. 21) for the area in and adjacent to Gila County. Although it might be desirable to have additional measurements in some parts of the area, we believed that the existing data are sufficient to suggest a shape for at least part of the basin.

All three isopach maps suggest that the basin of deposition contained a baylike area that extended into eastern Gila County and became wider and deeper to the west, although the deepest part of the basin is farther south. This suggested shape is somewhat different from that postulated or inferred by earlier workers whose data were largely from local work or reconnaissance studies.

The most persistent features of the Dripping Spring Quartzite as shown on the isopach maps are thinning to the north and southeast and the apparent thickening in a westerly and southwesterly direction. Thinning to the north had been well substantiated by previous workers. Reagan (1903) was the first to postulate a landmass separating the Apache basin from the Grand Canyon basin to the north-northwest. Ransome (1916, p. 165–166) presented more evidence concern-

TABLE 8.—*Stratigraphic sections used to prepare isopach maps*

Section	*Source*
1. Ash Creek	Ross, 1925b
2. Barnes Peak	This report
3. Bull Canyon	In 2 parts, this report
4. Canyon Creek	This report
5. Cherry Creek	In 2 parts, this study, not described
6. Coolidge Dam	This report
7. Copper Mountain	In 2 parts, this report
8. Delshay Basin	Darton, 1925
9. DeVore Wash	This report
10. Diamond Butte	Gastil, 1953
11. Gerald Wash	This report
12. Gordon Canyon	Gastil, 1953
13. Haigler Creek	This report
14. Horse Mountain	Gastil, 1953
15. Houdon Mountain	Do.
16. Middleton Mesa	This study, not described
17. Natanes	In 3 parts, this report
18. Needles Eye	Darton, 1925
19. Pine Mountain	This study, not described
20. Pioneer	In 2 parts, this report
21. Potts Canyon	This report
22. Red Bluff	In 2 parts, this report
23. Rock and Turkey Canyons	Gastil, 1953
24. Roosevelt Dam	This report
25. Ruin Basin	Bejnar, 1950
26. Snakebit	This report
27. Stanley district	This study, not described
28. Tomato Juice	This report
29. Walnut Creek	Do.
30. Wilson Creek	Do.
31. Workman Creek	Do.

ing this land barrier, and noted that the Barnes-like strata in the southwest corner of the Diamond Butte quadrangle contains angular fragments suggestive of a nearby source. Darton (1925, p. 235) pointed out that Apache rocks thin and overlap older sedimentary rocks of Precambrian age in the Haigler Creek–Gordon Creek area northeast of the Diamond Butte quadrangle. Stoyanow (1936, p. 462) named the land barrier between Apache and Grand Canyon rocks Mazatzal land and showed that it had continued to influence sedimentation during most of the Paleozoic Era.

Thinning of the Dripping Spring near Coolidge Dam is compatible with earlier observations by Darton (1925, p. 255) who described areas at the southeast end of the Mescal Mountains where Troy Quartzite overlaps the eastward-thinning Apache Group and ultimately rests directly on granite.

The trough of the Apache basin or embayment apparently trends westward or southwestward between the northern Sierra Ancha and the Coolidge Dam areas. The eastward extension can only be surmised from the thickness of the Natanes and Canyon Creek sections, but there is no evidence to suggest that the east boundary of the basin of deposition extended more than a short distance outside Gila County.

Our conclusion that the basin continued deeper to the west and particularly to the west-southwest, rather than abruptly terminating on the east flank of the Mazatzal Mountains, is based largely on the examination of sections at Copper Mountain, Red Bluff, Roosevelt Dam, and Potts Canyon. One of the thickest sections of Dripping Spring observed is at Copper Mountain, where, in general, the grain size of the rocks is relatively fine, particularly in the Barnes Conglomerate Member. A thick section of relatively fine grained material was also measured at Red Bluff. The section at Roosevelt Dam is less than 2 miles east of an inferred overlap, shown on a map by Wilson (1939, pl. 12), of Dripping Spring and Pioneer onto granite

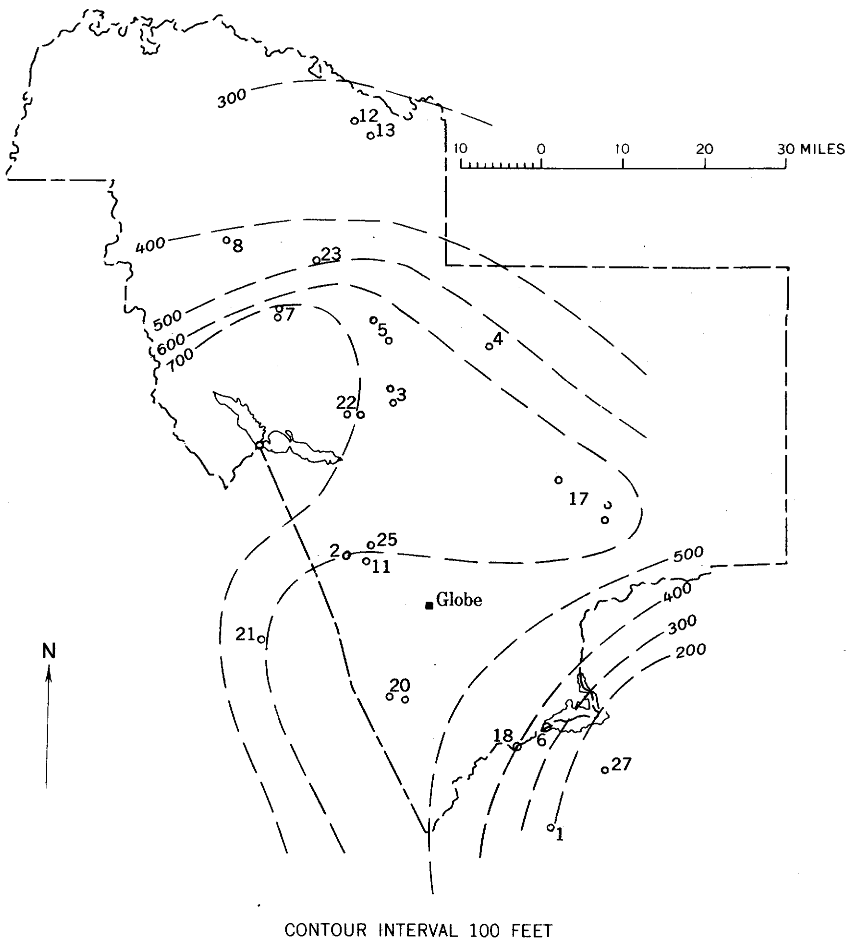


Figure 18.—Isopach map of the Dripping Spring Quartzite, Gila County, Ariz. Numbers refer to stratigraphic sections in table 8.

of Precambrian age in the Mazatzal Mountains. If such an overlap existed, it might be expected that the Dripping Spring section would be thinner and the grain size of the material larger, less well rounded, and more poorly sorted. This, however, is not the case. The section is the thickest measured, the grain size of the rocks, although perhaps greater than at Copper Mountain and Red Bluff, is not significantly larger, and the sorting is no poorer than at other sections. The Barnes at Roosevelt Dam is similar to that at Red Bluff in size, shape, composition, and roundness of constituent materials. It would be unusual if such an abrupt termination could take place without more geologic evidence being present only 1 or 2 miles away.

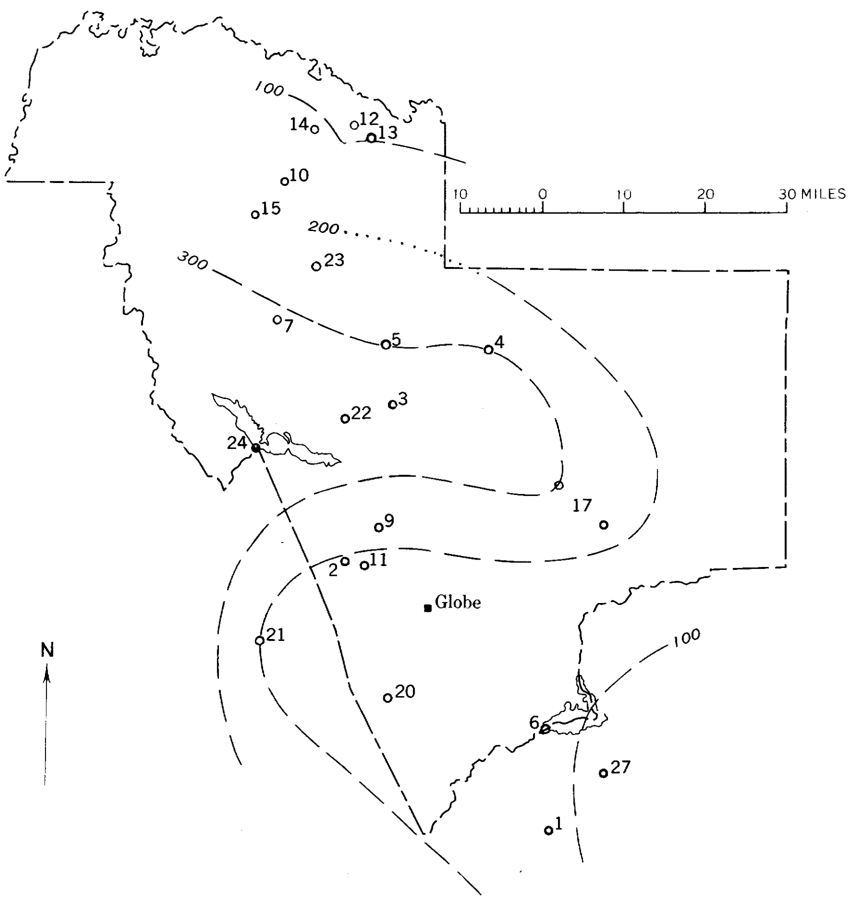
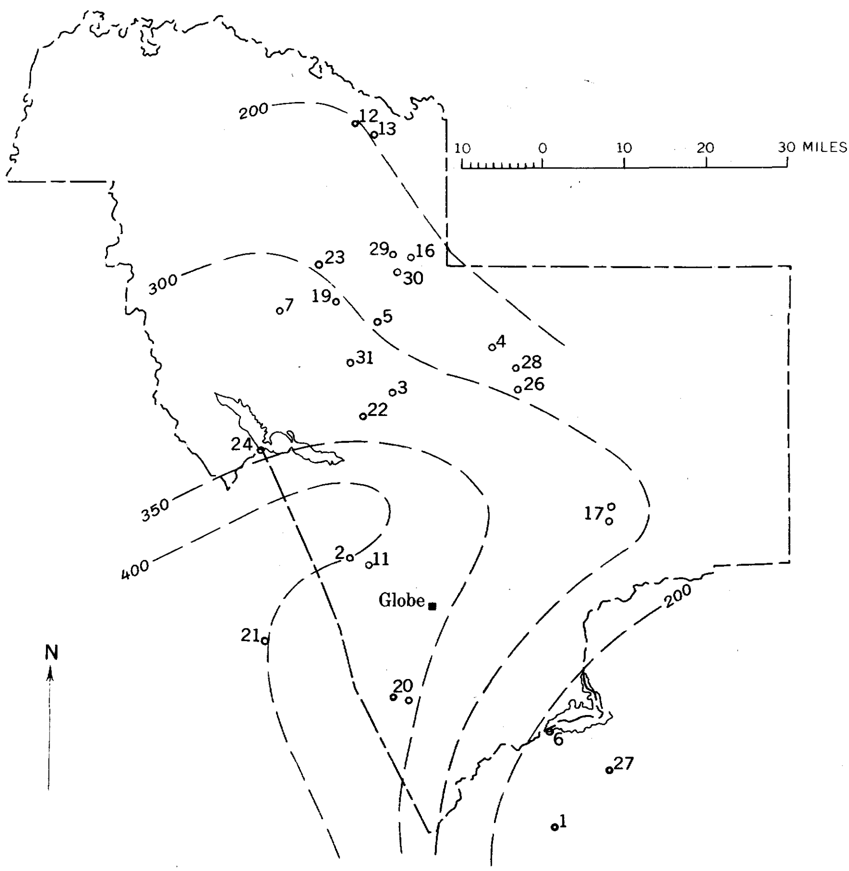


FIGURE 19.—Isopach map of the middle member of the Dripping Spring Quartzite, Gila County, Ariz. Numbers refer to stratigraphic sections in table 8.

The western, southwestern, and southern extensions of the basin in Maricopa, Pinal, and Cochise Counties are difficult to outline because outcrops of the Dripping Spring Quartzite are rare and only locally were they studied in detail (table 9). No evidence of the extent of deposition of Dripping Spring has been noted west of Gila County, but deposition far to the south and southwest is indicated by exposures along the San Pedro River and in southwestern Pinal County; the most southern outcrop of the formation is about 27 miles southeast of Tucson and about 80 miles south of Coolidge Dam. The trough of the basin or embayment may trend southwest-



CONTOUR INTERVALS 50 AND 100 FEET AS LABELED

Figure 20.—Isopach map of the upper member, Dripping Spring Quartzite, Gila County, Ariz. Numbers refer to stratigraphic sections in table 8.

ward from Gila County, as is suggested both by the general trend of the isopachs and by the unusually thick sections of Dripping Spring in southwestern Pinal County. Carpenter (1948) estimated more than 765 feet of Dripping Spring to be present in the Vekol Mountains, and Hogue (1940) measured 850 feet of Dripping Spring in the Slate Mountains.

The foregoing data suggest that the so-called Apache basin may well have been a large embayment extending generally northeastward from a much larger sea to the southwest.

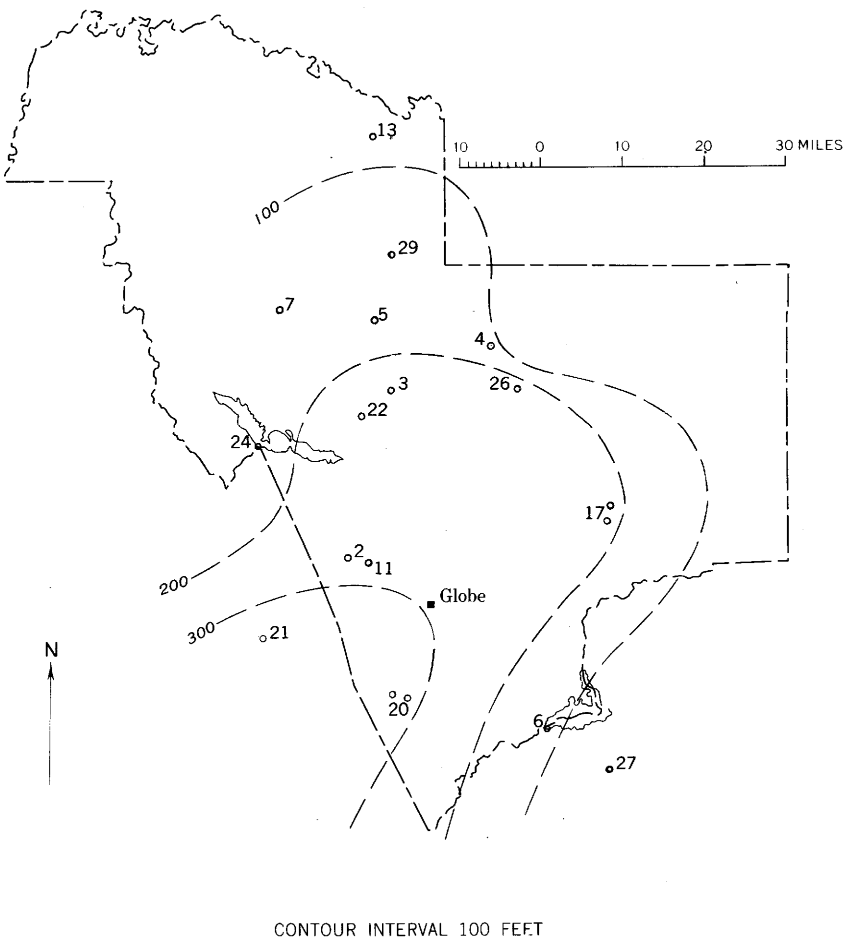


FIGURE 21.—Isopach map of the red and gray units of the upper member, Dripping Spring Quartzite, Gila County, Ariz. Numbers refer to stratigraphic sections in table 8.

TABLE 9.—*Thickness, in feet, of the Dripping Spring Quartzite at selected localities in southeastern Arizona*

Locality	Reference	Member			Formation total
		Barnes	Middle	Upper	
Gila County					
Barnes Peak	This report	17	186	396	599
Bull Canyon	do	22	305	338	665
Canyon Creek	do	25	302	210	537
Coolidge Dam	do	1	042	180	323
Copper Mountain	do	25	344	338	707
Delshay Basin	Ransome (1916)	2	[1] 150	240±	390±
DeVore Wash	Gastil (1953)	16	197	330	533
	This report	4	247	[2] 204	455+
Gerald Wash	Gastil (1953)	27	146	403	576
	This report	19	180	357	556
Gordon Canyon	Gastil (1953)	------	------	287	287
Haigler Creek	This report	------	------	214	[4] 355
Natanes	do	6	308	329	643
Needles Eye	Darton (1925)	Not given	400		400+
Pioneer	Gastil (1953)	18	175	379	572
	This report	8	193	369	570
Potts Canyon	do	8	200	397	605
Red Bluff	do	4	355	337	696
Rock and Turkey Canyons	Gastil (1953)	10	158	300	468
Roosevelt Dam	This report	17	369	322	708
Ruin Basin	Bejnar (1950)	5–35	200	470	690
Pinal County					
Campo Bonito area	Ludden (1950)[5]	35	280		[3] 315
Canada del Oro	Wallace (1951)	5–30	665 to 675		690
Peppersauce Wash	Stoyanow (1936)	37	300	(6)	337?
Slate Mountains	Hogue (1940)	2–4	850		850
Tortilla Mountains	Schwartz (1954)	0–50	[7] 750		750
Vekol Mountains	Carpenter (1948)	0–18	[1] 225	540	775
Cochise County					
Little Dragoon Mountains.	Cooper and Silver (in press).	3–15	304		[2] 313

[1] Division between middle and upper members made by us on basis of lithologic description.
[2] Top of section not present.
[3] Given as an approximate thickness.
[4] See description of measured section, this report.
[5] Ludden, R. W., Jr., 1950, Geology of the Campo Bonito area, Oracle, Arizona: Thesis, Univ. Arizona, Tucson.
[6] The upper member may be included, in part at least, in 325 feet of "unnamed sandstone" that is described as overlying the Dripping Spring.
[7] Maximum.

DEPOSITIONAL HISTORY AND ENVIRONMENTS

Available evidence indicates that the depositional environment of the Dripping Spring was characterized by fluctuating shorelines, transgressive deposition, and shallow streams and seas whose beds remained very near the base level of erosion for long periods of time.

Earlier attempts to explain the depositional history (Ransome, 1903 and 1919; Gastil, 1953; and others) left certain questions unanswered. For example, how were the gravels of the Barnes Conglomerate Member washed across the fine-grained detritus of the Pioneer Formation without leaving pronounced irregularities in the upper surface of the Pioneer? This is particularly puzzling if the gravels are presumed to have been derived in Gila County and washed as far as the Vekol and Little Dragoon Mountains 100 miles away. Earlier writers fail to explain the apparent increase of grain size and quartz content from base to top of the middle member. Also unknown are the reasons for apparently conflicting evidence concerning lateral variation in grain size, directions of cross-stratification, and dips of imbricate stones.

Tentatively, the history and environment can be reconstructed as follows: Upon conclusion of deposition of the Pioneer Formation in the area that is now Gila County the shallow sea covered an area of low relief. Offshore islands of lower Precambrian rocks locally dotted the sea, and the surrounding terrane, consisting of low rolling hills, was relatively featureless. Withdrawal of the sea at this stage, accompanied by uplift at the margins of the basin, resulted in vigorous subaerial erosion and sedimentation.

The highlands were mantled by talus debris, and some of the debris was washed out over parts of the basin. Where the streams carrying the debris reached the areas underlain by Pioneer Formation, their gradient was greatly reduced and they transported mainly the finer detritus, the gravel component being relatively small.

The source of the gravels and associated detritus is not known, but it is postulated that much of the material may have come from southeast of Gila County, derived from older metamorphic and igneous rocks that have since been completely removed or are now represented by remnants still largely buried by younger rock. To the north, local mantles of fanglomeratelike debris formed on the sides of monadnocks of basement rock and on the old coast line. These became rocks similar to the Barnes Conglomerate Member.

The sea, which had withdrawn to the west or southwest, now began again to inundate the Gila County area. As the sea advanced it met and overrode the outwashed gravel and other detritus. Wave action further rounded and sorted the debris and along-shore currents distributed the gravels. The coarser material was deposited near shore, and the finer arkosic to quartzose debris was deposited in less turbulent water offshore. To the north the angular and subangular fanglomeratelike debris continued to be contributed to the basin and formed both strata equivalent to the Barnes and conglomerates higher in the stratigraphic section. As the sea advanced, it reworked the subaerially deposited debris, and planed the underlying Pioneer Formation at wave base, thus obliterating most channels along which the gravels had been subaerially transported.

When the sea reached its maximum advance, feldspar-rich sands sorted from the original debris were being deposited in most of Gila County. These sands formed the lower part of the middle member. Both the Barnes Conglomerate Member and the lower part of the middle member, therefore, transgress time lines, the conglomerate nearer the shore corresponding in time to arkosic sandstones that overlie the conglomerate farther out in the basin.

At this point the sea began to retreat again because sedimentation had exceeded the rate of subsidence of the basin. Another mantle of conglomerate would have been deposited had such debris been available, but instead only sand and finer material were now being contributed from the land. Wave action at the shoreline reworked and sorted the sand, removing much of the feldspar and finer material. The littoral zone of the retreating sea is represented by the relatively pure orthoquartzite strata near the top of the middle member.

As the sea withdrew from the Gila County area, the coastline of emergence was characterized by great exposures of tidal or mud flats somewhat similar to but vastly larger than the flood plain that forms the lower reaches of the Colorado River delta today. On the flats were deposited fine sand, silt, and clay derived from the now very subdued land areas around the basin. Organisms, largely one-celled, that lived on the flood plains contributed to the carbon content of the gray unit. In Gila County much of the detritus deposited in the red, gray, and buff units of the upper member may have come from the south and east. Perhaps tuffaceous volcanic debris contributed to the upper member but evidence in the form of shards and lapillae is lacking.

The contact between the marine sandstones of the middle member and the flood-plain deposits of the red unit may also transgress time lines, and may be older near the edge of the basin than near the center.

Conditions during deposition of the red, gray, and buff units of the upper member were, for the most part, fairly well balanced; sedimentation in the basin closely matched subsidence, and throughout the time of deposition the base level of the basin and the supply of detritus to the basin remained moderately constant. The gray sandstone, sandstone lenses in the gray and black facies, and truncated preconsolidation slump structures in the buff unit indicate times when the balance was disrupted.

After deposition of the fine-grained part of the buff unit, the sea again advanced on the land and deposited the white quartzite marker at the shoreline and siltstones of the white unit farther out in the basin. Culminating this time of relative quiescence, cherty limestone strata were apparently deposited on top of the white unit. Uplift at the margin of the basin and adjustments within the basin, however, caused the cherty limestone and much of the white unit to be ripped up and mixed with coarse-grained metamorphic quartz sand derived from the surrounding land areas. This material formed the poorly sorted sandstone, arenaceous mudstone, and sedimentary breccia that marks the base of the Mescal Limestone in Gila County. If the erosion was confined to areas near the margin of the basin, it is probable that in deeper parts of the basin to the southwest of Gila County the Dripping Spring may be gradational into the Mescal with no evidence of erosion between their periods of deposition.

With erosion of the white unit and subsequent deposition of the basal strata of the Mescal on the erosion surface, gentle subsidence returned to the Gila County area and the argillaceous carbonate rocks typical of most of the lower part of the Mescal were deposited.

Although the area of deposition of the Apache Group has commonly been regarded as a closed basin, we postulate that the Apache was deposited in an embayment or arm of a much larger sea to the south and southwest. It is possible that the Grand Canyon Series, the Pahrump Series of California, and the Apache Group were all deposited shoreward in large embayments along the margin of the same sea.

MEASUREMENT OF SECTIONS, AND TERMINOLOGY USED

Most sections were measured with Brunton compass and steel tape; thicknesses were calculated from the strike and dip of the strata and the vertical angle and azimuth of the tape. The Walnut Creek and Snakebit sections as well as sections not described in detail herein were measured by hand level.

The classification of rock types of the Dripping Spring used in this report is based on grain size, composition, and induration. Methods of determining grain size and induration, and the terminology used for each, are described in sections that follow. The compositions of rock units were determined in the field with the aid of a hand lens. Relative amounts of quartz, feldspar, and mica were estimated. The abundance of pyrite, limonite, specularite, and clay minerals were noted where significant.

ROUNDNESS AND SHAPE (SPHERICITY)

Roundness and shape were estimated in the field and were recorded only for stones (p. 75). Shape terminology for stones of a moderate to high degree of roundness is that proposed by Zingg (in Krumbein and Sloss, 1951).

The degrees of roundness were classified in the field as follows:

Well rounded.—All edges and corners well worn and rounded; flat faces rare except on disks and blades. Shapes irregular but most commonly spheroidal.

Subrounded.—Same as above except that edges and corners are less well rounded and flat faces not quite so rare. Flat faces show the effects of abrasion.

Subangular.—Edges slightly rounded, flat faces common, shapes irregular. Flat faces less affected by abrasion.

Angular.—Sharp edges, flat surfaces very common, shapes very irregular. Few effects of abrasion on edges, corners, and faces.

SORTING

The degree of sorting of particles greater than clay size was estimated in the field and described according to the following classification:

Well sorted.—Particles in individual strata or sets of strata largely within the limits of two adjacent size grades.

Moderately sorted.—Particles span three adjacent size grades in individual strata or sets.

Poorly sorted.—Particles span four or more size grades in individual strata or sets.

INDURATION

The degree of induration of the rocks was estimated in the field; the effects of alteration and jointing were allowed for. Few individual rock units are so uniform that one term is applicable throughout. Therefore, a term describing the average degree of induration was recorded.

Terms, and their definition, used to describe the degree of induration are:

Poorly indurated.—Rock crumbles or breaks in the hand.

Moderately indurated.—Rock crumbles or breaks along numerous very rough fracture surfaces when struck with a hammer.

Well indurated.—Rock breaks along relatively few sharply defined fractures when crushed with a hammer. Fractures may or may not have vitreous luster and may or may not break across the grains. Conchoidal fractures not uncommon.

Quartzitic.—Rock breaks as above but fractures have vitreous luster and break across grains. Conchoidal fractures not uncommon. Term is largely reserved for quartzose rocks in which quartz content is everywhere greater than 75 percent and most commonly greater than 90 percent.

Novaculitic.—Rock breaks with sharply defined, principally conchoidal fractures. Term used only for dense, extremely fine grained, silica-rich rocks.

COLOR

Colors were determined in the field by direct comparison with the "Rock-Color Chart" (Goddard and others, 1948). Representative chips were hammered from the rocks and colors were recorded for both the weathered and freshly broken surfaces. The dominant colors were chosen in all examples; the range of colors at each exposure was much broader than is indicated by the recorded colors.

Color data presented are not, in many instances, a true indication of the color of the fresh rock. In general, rock exposed at the surface is badly weathered and oxidized, and rock exposed by breaking with a hammer is not sufficiently far from the surface to be called truly fresh. Thus the color of rock exposed by hammering can only be called the color of freshly broken rock. Only from diamond-drill cores and subsurface mine workings can reliable data on fresh rock be obtained. In the preceding general descriptions of rocks in the Dripping Spring Quartzite, data on the color of fresh rocks have been incorporated wherever they were available.

RADIOACTIVITY

Measurements of the radioactivity of Dripping Spring rocks were made with a portable scintillation meter. The instrument was held adjacent to the rock surface. Radioactivity data are averages of many measurements in each described interval, and measurements affected by proximity to concentrations of uranium minerals were noted separately. The detection instrument was carefully calibrated prior to the measurement of each section.

ROCK TYPES

The principal terms used for classifying rock types are defined as follows:

Claystone.—Rock composed largely of clay-size particles.

Siltstone.—Rock composed of silt-size particles.

Arenaceous.—Used as a modifier for claystones and siltstones that contain a moderate amount of very fine to coarse sand grains.

Argillaceous.—Used as a modifier for siltstones and sandstones which contain megascopically notable amounts of detrital clay. Clay presumed to be derived from alteration of constituent feldspars was excluded.

Sandstone.—Rock composed largely of very fine- to coarse-grained sand particles.

Conglomeratic.—Rock in which stones larger than granule size are common, but constitute less than 50 percent of the total rock.

Orthoquartzite.—Sandstone cemented by silica. Not a product of dynamic metamorphism. Rock has a vitreous luster and breaks across rather than around grains. When the term is used alone, without a compositional modifier, it denotes a rock composed of more than 90 percent quartz.

Feldspathic.—Modifier used to denote a rock that contains more than 10 percent but less than 25 percent feldspar.

Arkosic.—Modifier used to denote rock that contains more than 25 percent feldspar.

Micaceous.—Modifier used to denote rock that contains detrital mica, particularly on stratification planes. Mica rarely more than 5 percent.

GRAIN SIZE

Grain size was determined in the field by direct comparison with a grain-size chart containing examples of size classifications corresponding to the Wentworth scale as given in modified form in Krumbein and Pettijohn (1938, p. 80). Sizes of granules, pebbles, cobbles, and boulders, herein called stones, were determined by direct measurement.

STRATIFICATION

The terminology of stratification and cross-stratification follows the proposals of McKee and Weir (1953) (table 10).

A set, as defined by McKee and Weir (1953)—

> . . . is a group of essentially conformable strata or cross-strata, separated from other sedimentary units by surfaces of erosion, nondeposition, or abrupt change in character. It is the smallest and most basic group unit.

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Studies of the direction of dip of cross-strata were made by measuring the bearing of apparent dip on many exposures in a given stratigraphic section. The results, after corrections for strike and dip of the rocks, can be regarded as suggestive of the general direction of dip.

A type of cross-stratification, herein called wispy cross lamination, refers to a variety of small-scale, low-angle trough cross-stratification in which the individual sets appear to grade into one another. It is apparently formed by a myriad of small anastomosing rills that have cut-and-filled in a complex network.

TABLE 10.—*Comparison of quantitative terms used in describing layered rocks*

[From McKee and Weir (1953)]

Terms to describe stratification		Terms to describe cross-stratification		Thickness of rock unit	Terms to describe splitting property
Very thick bedded	Beds	Very thickly cross-bedded.	Cross beds	>120 cm	Massive.
Thick-bedded		Thickly cross-bedded.		120 cm (≈ 4 ft). to	Blocky.
Thin-bedded		Thinly cross-bedded.		60 cm (≈ 2 ft). to	Slabby.
Very thin bedded		Very thinly cross-bedded.		5 cm (≈ 2 in.) to	Flaggy.
Laminated	Laminae	Cross-laminated	Cross-laminae	1 cm (≈ ½ in.). to	Shaly (claystone, siltstone). Platy (sandstone, limestone).
Thinly laminated.		Thinly cross-laminated.		2 mm (≈ 0.08 in.) or less.	Papery.

SPLITTING PROPERTY

The splitting property of a sedimentary rock does not necessarily correspond in thickness to the stratification. Although the rock generally splits on a stratification plane, the interval between these splits may comprise several strata. Commonly the rock splits between sets of strata. The splitting property is principally an outcrop characteristic and is accentuated by weathering.

The terminology of the splitting property is that included in a report by McKee and Weir (1953; table 10, this report).

STRATIGRAPHIC SECTIONS

BARNES PEAK SECTION

East flank of Barnes Peak, Inspiration 7½-minute quadrangle

	Thickness (feet)
Dripping Spring Quartzite:	
Upper member:	
Buff unit (incomplete):	
11. Sandstone, feldspathic, very pale organge to pale-yellowish-brown plus hematite stain; well indurated, very fine to medium grained, largely fine grained; slabby, laminated, apparently structureless; weathers very pale orange to yellowish orange; forms ledges	25
Gray unit:	
Black facies:	
10. Siltstone, medium-light-gray to light-olive-gray; well indurated, flaggy, laminated; crumpled mud cracks, stylolites; weathers pale reddish, brown, pale yellowish brown, and light brown; forms rubble-covered slope except for a few subdued outcrops	67
Gray facies, gray sandstone and barren quartzite:	
9. Sandstone, light-olive-gray to dusky-yellow; well indurated, fine grained to silty, generally very fine grained; flaggy and slabby, laminated and faint low-angle trough cross-lamination; abundant stylolites; poorly exposed; weathers dusky red to pale red and yellowish gray; forms ledges where exposed, rubble-covered slopes elsewhere	96
8. Sandstone with shaly partings; micaceous shales are grayish orange; sandstone is light brownish gray to grayish orange pink; well indurated, very fine grained to silt; shales are platy; sandstones are flaggy and slabby; shale weathers grayish orange; sandstone weathers pale olive gray to light olive gray; forms rubble-covered slope	51
Red unit:	
7. Shale and sandstone, interstratified in layers 2 in. to 4 ft thick; forms ledgy slope.	
Shale: Silty, micaceous, hematitic, grayish-red; moderately to well indurated, flaggy and platy, laminated and thinly laminated; weathers grayish-red to pale red; forms slope.	
Sandstone, arkosic, pale-red to pale-yellowish-brown; well indurated to quartzitic, very fine grained to silty; slabby and flaggy, laminated and cross-laminated; weathers pale red to grayish orange and pale yellowish brown; forms ledges	74
Total incomplete upper member	313

	Thickness (feet)
Dripping Spring Quartzite—Continued	
Middle member:	
6. Sandstone, feldspathic, grayish-orange to grayish-orange-pink; well indurated to quartzitic, fine to medium-grained; blocky, cross-laminated, laminated and very thin bedded; feldspar largely altered to clay; weathers grayish orange to light brown plus surficial limonite stain; forms ledges with local cliffs	45
5. Orthoquartzite, hematitic, grayish-pink; quartzitic, medium grained, massive, cross-laminated; many small limonite-filled cavities after specularite(?) in the cement; weathers grayish pink; forms ledges and cliffs	15
4. Sandstone, arkosic(?), argillaceous (secondary), pale- and grayish-red to grayish orange-pink; moderately to well indurated, very fine to medium grained, moderately sorted; slabby, laminated, and very thin bedded; contains many chert laminae; weathers to alternating grayish-red and grayish-orange strata; forms slope	42
3. Sandstone, feldspathic, disseminated specularite, pale-red to grayish orange-pink; well indurated to quartzitic, fine to coarse grained, medium grained average; blocky to massive, cross-laminated in lenticular cosets; weathers pale red to pale yellowish brown; forms ledges	41
2. Sandstone, arkosic, pale to grayish red-purple and grayish-pink; moderately to well-indurated, fine-to coarse-grained, medium grained average; blocky to massive, locally splits on cross-strata; cross-laminated and very thinly cross bedded; strata that weather grayish orange pink and light brown interstratified with strata that weather grayish red; forms ledges	43
Total middle member	186
Barnes Conglomerate Member:	
1. Conglomerate, grayish-orange-pink, massive, interstratified with sandstone lenses; moderately well indurated to quartzitic; forms cliff. Matrix: Feldspathic sandstone and orthoquartzite, grayish-pink to grayish-orange; moderately indurated to quartzitic; fine to very coarse grained, averages coarse grained; massive, cross-laminated; weathers grayish orange-pink. Stones: 90 percent pebbles, less than 10 percent cobbles and granules; stones make up 50 percent of rock; well rounded, largely spheroidal, some disks; 80 percent quartzite, 15–20 percent vein quartz, less than 3 percent reddish jasper	17
Total Barnes Conglomerate Member	17
Total incomplete Dripping Spring Quartzite	516

NORTH BARNES PEAK SECTION

East flank of north Barnes Peak, Inspiration 7½-minute quadrangle

	Thickness (feet)
Mescal Limestone:	
14a. Quartzite, argillaceous and feldspathic, grayish-orange to pale-red; coarse grained to silty, average medium grained; poorly sorted, blocky; weathers grayish orange and pale red; forms ledge	3.5
Dripping Spring Quartzite:	
Upper member:	
White unit:	
13a. Siltstone, argillaceous, grayish-orange-pink; silty and clayey, laminated and very thinly laminated, platy; weathers grayish orange and grayish orange pink; forms slope	10.0
Buff unit, including white quartzite marker:	
12a. Orthoquartzite, light-brownish-gray, fine- to medium grained, blocky, 95 percent quartz. Weathers to grayish orange pink; abundant iron stain; forms ledge	4.0
11a. Sandstone, arkosic, grayish-orange-pink; well indurated, fine-grained average, flaggy and slabby, laminated and very thin bedded; wispy cross-lamination, abundant stylolites; weathers grayish orange pink plus abundant grayish-red iron stain; forms steep ledgy slope	94.0
Gray unit:	
Black facies (incomplete):	
10a. Siltstone, medium-dark-gray to medium-light-gray; moderately to well indurated, silty and very fine grained, flaggy, laminated; stylolites abundant and strongly iron stained; weathers grayish orange to light brown; forms ledgy slope	34.0
Total incomplete Dripping Spring Quartzite	142

Thickness of Dripping Spring at Barnes Peak based on tentative correlation between sections:

Upper member	396
Middle member	186
Barnes Conglomerate Member	17
Total Dripping Spring Quartzite	599

BULL CANYON SECTION

Barnes Conglomerate and middle member on South wall of Bull Canyon at confluence with Deep Creek, McFadden Peak quadrangle. Upper member on west wall of Deep Creek Canyon

	Thickness (feet)
Mescal Limestone:	
9. Orthoquartzite, locally feldspathic sandstone, yellowish-gray; poorly sorted, medium to coarse quartz grains in finer grained matrix; massive to blocky, structureless to cross-stratified; weathers to light olive gray to pale red; iron stained; forms ledge	6
Dripping Spring Quartzite:	
Upper member:	
White unit:	
8. Sandstone and orthoquartzite, feldspathic, grayish-orange-pink to yellowish-gray; fine to medium grained, largely fine grained; slabby to blocky, laminated and thinly laminated; weathers grayish pink and grayish orange pink; limonite stained; forms ledges	10
Buff unit, including white quartzite marker:	
7. Sandstone, and orthoquartzite, feldspathic, grayish orange pink to light gray; fine to coarse grained, largely fine grained; slabby to blocky; well-indurated and quartzitic, very thin-bedded to laminated and cross-laminated; mud cracks common; stylolites common; preconsolidation slump structure below a massive 4-ft-thick pock-marked bed at about 50 ft; top 3 ft coarser grained and probably corresponds to the white quartzite marker; weathers medium light gray to grayish pink; forms cliffs and local ledges	103
Gray unit:	
Black facies:	
6. Siltstone, arenaceous, dark- to light-gray and grayish-orange-pink; well indurated, platy to slabby, largely flaggy; thinly laminated to thin bedded, graded strata; stylolites common; weathers grayish orange pink with strong limonite stain; forms 35° slope	77
5. Orthoquartzite and sandstone, feldspathic, grayish-orange-pink very fine to medium grained, largely fine grained; moderately sorted, well indurated to quartzitic, slabby, laminated and cross-laminated; grades into underlying unit by interstratification; weathers yellowish gray with limonite stains; forms cliff or ledge	9
4. Siltstone, arenaceous, dark- to light-gray; well indurated, platy to slabby, largely flaggy; liminated and thinly laminated, abundant stylolites; weathers yellowish gray with limonite stains; forms 30° slope	20

Dripping Spring Quartzite—Continued
Upper member—Continued
Gray unit—Continued

	Thickness (feet)
Gray sandstone and barren quartzite:	
3. Sandstone, feldspathic, grayish-orange-pink; well indurated, fine grained, with thin coarse-grained stratum at top; moderately sorted, massive, structureless to cross-laminated; local preconsolidation slump structure; pock marked; weathers yellowish gray with limonite stain; forms cliff locally, elsewhere forms slope	19
Gray facies:	
2. Siltstone, arenaceous, yellowish-gray to medium-dark-gray; well indurated, platy to slabby, thinly laminated to very thin-bedded; mud cracks common; undulatory stratification; weathers yellowish gray; forms 30° slope	65
Red unit:	
1. Siltstone, arenaceous, moderate-red at base to light-brownish-gray at top; well indurated, slabby, laminated; local mud cracks; weathers moderate red at base to light brownish gray at top; forms cliff except for basal few feet which form slope	35
Total upper member	338
Middle member:	
8. Sandstone, feldspathic to arkosic, pale-red; very fine to fine-grained; thin-bedded and laminated, locally thinly crossbedded, blocky; weathers pale red and moderate red orange; forms ledges and slopes	56
7. Orthoquartzite, slightly feldspathic, grayish-orange-pink; medium grained, laminated to thin bedded, massive; several fine-grained arkosic sandstone partings less than 1 ft thick; weathers grayish orange pink; forms cliffs	24
6. Orthoquartzite, feldspathic, grayish-pink; fine-grained, very thin to thin-bedded, massive; weathers moderate reddish orange; forms cliffs	39
5. Orthoquartzite and sandstone; alternating intervals; weathers moderate reddish orange; forms cliffs. Orthoquartzite: Pale-red; fine to medium-grained; laminated and thinly laminated, cross-laminated and thinly cross-laminated, massive to blocky. Sandstone: Arkosic, moderate-orange-pink; fine to very fine grained, well indurated; laminated and thinly laminated, massive to flaggy, some cross-laminae	50
4. Sandstone, arkosic, moderate-orange-pink; medium-grained, quartzitic; thinly laminated, thinly cross-laminated, massive, locally flaggy; weathers moderate reddish orange; forms cliffs	67

	Thickness (feet)
Dripping Spring Quartzite—Continued	
Middle member—Continued	
3. Sandstone, arkosic, moderate-reddish-orange; very fine to fine-grained, quartzitic, laminated and thinly laminated, minor cross-lamination; massive; weathers moderate reddish orange, iron-stained; forms ledges	45
2. Sandstone, arkosic, quartzose, and ferruginous, pale-red; very fine grained, laminated and thinly laminated, blocky, some platy partings; mud cracks, oscillation ripple marks; weathers pale reddish brown; forms ledges	24
Total middle member	305
Barnes Conglomerate Member:	
1. Conglomerate, grayish-red; thick bedded, massive; weathers grayish red; forms resistant cliff. Matrix: Orthoquartzite, sandstone, and siltstone, grayish-red; arkosic, silty to coarse grained; laminated, rarely cross-laminated. Stones: ¼- to 8-in. diameter; well-rounded. Spheroids and some disks; composed of vein quartz, gray and red quartzites, and red jasper	22
Total Barnes Conglomerate Member	22
Total Dripping Spring Quartzite	665

CANYON CREEK SECTION

East side of Canyon Creek about 3 miles north of the Salt River in a canyon about 2,500 feet north of hill 4295, Blue House Mountain quadrangle

	Thickness (feet)
Mescal Limestone:	
9. Sandstone, silty, pale-red; well indurated, very fine grained to silty with about 10 percent coarse quartz grains; poorly sorted, massive and blocky, structureless; weathers pale red; forms cliff	5
Dripping Spring Quartzite:	
Upper member:	
Buff unit, including white quartzite marker:	
8. Sandstone, arkosic at base, feldspathic near top, light-brownish-gray; moderately to well indurated, very fine grained and silty near base increasing to fine grained with medium-grained lenses near top; top 7 ft probably corresponds to the white quartzite marker; flaggy and slabby, laminated, very thin-bedded and cross-laminated; stylolites; weathers light brown; forms cliff	104

	Thickness (feet)
Dripping Spring Quartzite—Continued	
Upper member—Continued	
Gray unit:	
Black facies:	
7. Siltstone, dark- to medium-gray; well-indurated, platy to slabby, laminated to very thinbedded; weathers medium gray to grayish red; forms cliff and smooth slope	24
Gray sandstone and barren quartzite:	
6. Sandstone, silty to feldspathic orthoquartzite, grayish orange to very pale orange; well indurated to quartzitic; very fine grained to silty with interstratified medium- and coarse-grained lenses; flaggy and slabby, laminated to thinbedded, shrinkage cracks in finer grained strata; stylolites abundant; weathers variegated grayish and very pale orange, pale red, pale red purple, and medium dark gray; forms cliff	33
Gray facies:	
5. Siltstone, micaceous, dark- to light-gray; well indurated, flaggy and slabby, shrinkage cracks, pseudochannels abundant from 4 to 14 feet; a few lenses of mud-plate conglomerate; weathers variegated light to medium bluish gray, yellowish to medium light gray, and pale yellowish brown; forms cliff	43
Red unit:	
4. Siltstone, very micaceous, dusky-red; well indurated, flaggy and slabby, mud cracks; weathers pale purple and pale red; forms cliff	6
Total upper member	210
Middle member:	
3. Sandstone, arkosic to feldspathic, grayish-red and moderate reddish-orange; well indurated, medium to very fine grained, blocky and slabby, cross-laminated; weathers grayish red to pale reddish brown; forms ledges	41
2. Orthoquartzite, feldspathic to nearly pure, commonly vitreous, pale-red to moderate reddish-orange; fine, medium, and coarse grained in interstratified sets; massive and blocky, cross-laminated to structureless; basal 4 ft is a grayish-red fine-grained arkosic sandstone; a few lenses containing scattered feldspar, jasper, and quartzite granules and pebbles in the lower 20 ft of unit; weathers pale red to moderate reddish orange; forms cliff	261
Total middle member	302

	Thickness (feet)
Dripping Spring Quartzite—Continued	
Barnes Conglomerate Member:	
1. Conglomerate, pale-red; massive, structureless, well indurated, poorly exposed; forms cliff. Matrix: Arkosic, pale-red; well indurated, medium- to coarse-grained; weathers pale red. Stones: 10 percent cobbles, 55-65 percent pebbles, 25–35 percent matrix; largely spheroidal, a few disks, well rounded; composed of about 60 percent quartzite and 40 percent vein quartz	25
Total Barnes Conglomerate Member	25
Total Dripping Spring Quartzite	537

COOLIDGE DAM SECTION

Between U.S. Highway 70 and San Carlos Lake about 1 mile east of Coolidge Dam (not shown on quadrangle map), Christmas quadrangle

	Thickness (feet)
Mescal Limestone:	
13. Mudstone, arenaceous, brownish; contains breccia fragments of siltstone and black chert	4
12. Silt and clay, contains poorly sorted quartz grains, greenish gray; structureless, on an erosional surface	1
Dripping Spring Quartzite:	
Upper member:	
White unit:	
11. Siltstone, alternating with fine-grained sandstone similar to 10; siltstone is yellow green, poorly to moderately indurated, clay to silt, platy to slabby, laminated and structureless; weathers light greenish gray and grayish yellow green; forms slope	5
Buff unit:	
10. Sandstone, arkosic; with some orthoquartzite lenses; pale-brown, light-brown, and pale-yellowish brown to grayish-orange; well indurated; very fine grained and silt with local medium- and coarse-grained lenses; slabby to platy, cross-laminated and laminated; mud cracks common; stylolites abundant; mud-plate conglomerate lenses rare; weathers grayish orange and dark yellowish orange to dark reddish brown; forms cliff	61
Gray unit:	
Black facies(?):	
9. Rubble-covered slope with no exposure	13
Gray sandstone and barren quartzite:	
8. Sandstone, feldspathic, pale-red to pale-yellowish-brown; well indurated to quartzitic, very fine grained at bottom to coarse grained at top; slabby with platy partings; cross-laminated and laminated, increases upward in purity and grain size; topmost bed is 2 ft of coarse-grained orthoquartzite; weathers light to pale brown; forms ledge	16

Dripping Spring Quartzite—Continued

Upper member—Continued

Gray unit—Continued

	Thickness (feet)
Gray facies:	
7. Claystone, greenish-gray; poorly to moderately indurated, platy, nonfissile, structureless to laminated; contains many interstratified, thin-bedded, very fine grained and silty sandstone lenses; weathers grayish green; forms slope	27
Red unit:	
6. Sandstone, feldspathic, pale-red; well indurated, silicified, very fine grained; flaggy and slabby, laminated, wispy cross-lamination; local preconsolidation slump structures; weathers grayish red; forms ledge	11
5. Siltstone, argillaceous, micaceous, hematitic, grayish-red and greenish-gray; platy and papery; contains many flaggy and thin slabby, very fine grained, moderate-reddish-orange interstratified sandstone lenses; mud cracks and cusp-shaped ripple marks common; weathers grayish red and greenish gray; forms slope	47
Total upper member	180
Middle member:	
4. Orthoquartzite, feldspathic, pale-red to moderate orange-pink; fine to medium grained, well indurated, slabby, cross-laminated, rare ripple marks; pock-marked beds in topmost strata; weathers pale red; forms ledges	48
3. Sandstone and orthoquartzite, feldspathic, grayish-pink; medium grained with scattered granules, blocky and massive, cross-laminated; weathers pale red; forms cliff	72
2. Sandstone, arkosic, grayish- to pale-red; well indurated, fine to medium grained, slabby to blocky, cross-laminated and structureless; scattered pebbles in lower part; weathers grayish red to moderate reddish orange; forms cliff	22
Total middle member	142

	Thickness (feet)
Dripping Spring Quartzite—Continued	
Barnes Conglomerate Member:	
1. Conglomerate, grayish- to pale-red; slabby, well indurated; forms cliff. Matrix: Sandstone, arkosic, grayish- to pale-red; well indurated, fine to medium grained, slabby, cross-laminated and structureless; weathers grayish red to moderate reddish orange. Stones: Compose 50 percent of rock, about 2 percent small cobbles, 80 percent pebbles, 8 percent granules; well-rounded spheroids; composed of quartzite and vein quartz	1
Total Barnes Conglomerate Member	1
Total Dripping Spring Quartzite	323

COPPER MOUNTAIN SECTION

Barnes Conglomerate Member and middle member on east side of south-trending canyon about 6,500 feet southwest of Copper Mountain

Upper member on east side of a canyon on the west flank of Copper Mountain, Roosevelt quadrangle

	Thickness (feet)
Dripping Spring Quartzite:	
Upper member:	
Buff and white units, including white quartzite marker(?):	
11. Sandstone and siltstone, arkosic, medium- and olive-gray to moderate-orange-pink and pale-red; well indurated, fine grained to silty, largely very fine grained; slabby; laminated and very thin bedded to structureless; cross-laminated in coarser grained strata; shrinkage cracks, stylolites; 1-foot thick cross-laminated orthoquartzite at 119–120 ft. probably is white quartzite marker; weathers pale yellowish brown to very pale orange; strongly weathered and leached; forms ledges and slope	155
Gray unit:	
Black facies:	
10. Siltstone, dark- to medium-gray; well indurated, platy to slabby, largely flaggy; laminated, shrinkake cracks, stylolites; weathers very dusky red and grayish red to greenish gray; forms ledges and slope	82
Gray sandstone and barren quartzite:	
9. Orthoquartzite, feldspathic to pure, dusky yellow at base to light-brownish-gray at top; well indurated to quartzitic, very fine grained with silty splits; blocky orthoquartzite with platy siltstone splits; laminated and structureless, ripple marks; weathers light brown to yellowish gray at base to light brownish gray at top; forms cliff	31

Dripping Spring Quartzite—Continued
Upper member—Continued
Gray unit—Continued

	Thickness (feet)
Gray facies:	
8. Siltstone, yellowish-gray to light-olive-gray; well indurated, flaggy to slabby, laminated and very thin bedded, a few shrinkage cracks, metamorphic spots; weathers grayish orange to grayish yellow; forms cliff and ledges	29
7. Sandstone, arkosic, pale-reddish-brown to medium-dark-gray and greenish-gray; well indurated, very fine grained to silty, slabby, laminated to structureless, with pseudochannels, ripple marks, metamorphic spots locally; malachite stain locally in lower 30 ft.; weathers grayish orange pink and light brown to dusky red; forms cliff and ledges	41
Total upper member	338
Middle member:	
6. Sandstone and orthoquartzite, alternating beds, forms ledges. Sandstone: Arkosic, moderate reddish-orange; moderately to well indurated, very fine grained and silty, flaggy and slabby, laminated, ripple marked; weathers moderate reddish orange to pale brownish red. Orthoquartzite: Feldspathic to nearly pure, moderate-orange-pink; quartzitic, fine to very fine grained; slabby and blocky, cross-laminated, pock marked; weathers pale red	31
5. Orthoquartzite and sandstone, alternating beds, pockmarked; forms ledges. Orthoquartzite: Feldspathic to pure, pale-red to grayish-pink; quartzitic, fine to coarse grained, largely medium grained; massive and blocky, cross-laminated and very thinly crossbedded, weathers pale red to grayish pink. Sandstone: Arkosic, pale-reddish-brown and moderate-reddish-orange to pale-red; well indurated, blocky and massive; cross-laminated and very thinly crossbedded; weathers pale brownish red and moderate reddish orange	62
4. Sandstone, arkosic, lower half moderate reddish orange; upper half moderate red; well indurated; lower half very fine to very coarse grained, poorly sorted; upper half very fine grained, moderately to well sorted; massive and blocky, cross-laminated and very thinly crossbedded, ripple marks; gradational to smaller grain size, darker color, more arkosic, better sorted toward top of interval; weathers reddish orange to moderate red; forms ledges and cliffs	147

	Thickness (feet)
Dripping Spring Quartzite—Continued	
Middle member—Continued	
3. Sandstone, arkosic to orthoquartzite, pale-red and moderate orange-red; fine to coarse grained, moderately to poorly sorted; massive and blocky, cross-laminated and very thinly crossbedded; cross-strata commonly graded from coarse-grained orthoquartzite to fine- and medium-grained arkosic sandstone; general tendency to coarser-grained, more quartzose strata toward top of interval; weathers moderate orange pink; forms ledges and cliffs	104
Total middle member	344
Barnes Conglomerate Member:	
2. Sandstone, conglomeratic, feldspathic to orthoquartzite, pale-red; well indurated to quartzitic, fine to very coarse grained in lower half, medium grained above; lower half poorly sorted, fair to moderately sorted above; laminated and very thinly crossbedded; rests on erosion surface cut in underlying interval; lower half contains about 10–15 percent granules, 5–10 percent pebbles, and less than 1 percent cobbles in about 75 percent matrix; composed largely of subangular feldspar and granite, subrounded vein quartz and well-rounded quartzite; weathers medium light gray to light gray; forms cliff	17
1. Sandstone, conglomeratic, feldspathic, pale-red with some light brown and grayish red; well indurated to quartzitic; medium and coarse grained with thin, graded, fine-grained strata at top of some cosets; massive and blocky, cross-laminated and very thinly crossbedded; contains about 15–20 percent granules, less than 10 percent pebbles, and less than 1 percent cobbles of well-rounded quartzite, subangular feldspar and granite, and subrounded vein quartz; weathers pale reddish brown to pale red; forms cliff	8
Total Barnes Conglomerate Member	25
Total Dripping Spring Quartzite	707

DeVORE WASH SECTION (INCOMPLETE AT TOP)

East side of DeVore Wash opposite Salt River Peak, Rockinstraw Mountain quadrangle

	Thickness (feet)
Dripping Spring Quartzite:	
Upper member (incomplete):	
Buff unit, incomplete:	
12. Diabase and faults	Not measured
11. Siltstone and sandstone, flaggy; forms cliff	31
Gray unit:	
Black facies:	
10. Siltstone, light-gray, papery; forms slope	41
Gray sandstone and barren quartzite:	
9. Sandstone and siltstone, contorted beds at base; forms cliff	17
Gray facies:	
8. Siltstone, gray to tan, papery; forms slope	84
Red unit:	
7. Siltstone, grayish-red, flaggy; weathers dark grayish red; forms ledgy slope	31
Total incomplete upper member	204
Middle member:	
6. Orthoquartzite, shaly partings, grayish-pink, well indurated, fine to very fine grained; blocky; very thinly crossbedded; weathers moderate orange pink; forms ledges	35
5. Sandstone, feldspathic, grayish-orange-pink; fine to medium grained, moderately indurated to quartzitic; slabby to blocky, laminated and cross-laminated, massive in quartzitic beds; ripple marks near top; weathers pale red; forms slope but ledgy near top	79
4. Sandstone, orthoquartzite bed at bottom, grayish-pink; well indurated, coarse grained; massive to platy, laminated, cross-laminated in massive units; weathers grayish orange pink; forms cliffs at top and bottom, slope between	38
3. Sandstone, quartzite layers, arkosic to feldspathic, moderate-orange-pink; well indurated, fine to medium grained; platy to blocky, laminated, cross-laminated in blocky parts; ripple marks near base; few siltstone layers; 5–10 ft at top is massive cliff with a few ½-in. pebbles; forms ledges and cliff	80
2. Sandstone, arkosic with pebble layers, grayish-orange; medium to coarse grained; massive to blocky, thinly laminated with well-developed cross-lamination; 2- to 3-in. layers of quartz, jasper, and quartzite pebbles; composed of about 70 percent quartz, 30 percent feldspar and clay; forms cliff	15
Total middle member	247

	Thickness (feet)
Dripping Spring Quartzite—Continued	
Barnes Conglomerate Member:	
1. Conglomerate, massive, poorly stratified, moderately indurated except top and bottom 6 in. well indurated; forms overhanging cliff; erosional contact at base. Matrix: Moderately reddish-orange; medium to very coarse grained; composed of quartz, jasper, feldspar, and clay. Stones: 50 percent of rock; well-rounded, spheroidal shapes predominant; average diameter 1–1½ in. 4 in. maximum; composed of quartz, quartzite, jasper	4
Total Barnes Conglomerate Member	4
Total incomplete Dripping Spring Quartzite	455

GERALD WASH SECTION

On northeast-trending ridge, south of wash about 1,000 feet westward from Dago Spring, Inspiration quadrangle

	Thickness (feet)
Mescal Limestone:	
10. Breccia, composed of quartzite fragments in poorly sorted mudstone matrix; quartz grains, white, vitreous; overlain by poorly sorted mudstone	0.5
Dripping Spring Quartzite:	
Upper member:	
Buff unit, including white quartzite marker:	
9. Orthoquartzite, argillaceous, medium-light-gray; medium grained, blocky to slabby, laminated and cross-laminated; weathers medium gray to moderate pink; limonite stained; forms ledge	3
8. Sandstone, argillaceous, light-brownish gray; fine to very fine grained, several medium-grain iron-rich quartzite beds; slabby; laminated and locally cross-laminated; stylolites common; weathers grayish orange pink with moderate red hematite stain along stylolites; forms slope	88
Gray unit:	
Black facies:	
7. Sandstone, silty, arkosic to feldspathic	81
Gray sandstone including barren quartzite:	
6. Orthoquartzite, very light gray, fine- to medium grained, largely fine grained; slabby, laminated and cross-laminated, poorly developed; weathers grayish with abundant limonite stain; forms ledges	8

Dripping Spring Quartzite—Continued

Upper member—Continued

Gray unit—Continued

	Thickness (feet)
Gray sandstone including barren quartzite—Continued	
5. Sandstone, arkosic, light-brownish-gray; well indurated to quartzitic, fine to very fine grained with local coarse-grained lenses; flaggy to blocky, largely slabby; laminated and cross-laminated to very thin bedded; wispy cross-stratification; pseudochannels common near base, mud cracks common, stylolites abundant; weathers pinkish gray, dusky-red hematite stain along stylolites and bedding planes; forms cliffs and ledges	49
Gray facies:	
4. Sandstone, arkosic, yellowish- to light olive-gray; indurated, very fine grained to silt, flaggy to slabby, laminated to very thin bedded, contains cherty quartzite lenses; stylolites rare; weathers dark yellowish orange to light brown; forms slope	65
Red unit:	
3. Sandstone, feldspatic and micaceous, pale-brown to pale-red; well to moderately indurated, flaggy to slabby, laminated; local lenses of medium-grained orthoquartzite, clay pebble conglomerate, and shale; weathers light to pale brown; forms steep slope	63
Total upper member	357
Middle member:	
2. The middle member is largely rubble-covered slope but the following are descriptions of local exposures within the member:	
d. Topmost strata in unit at 180 ft.: Sandstone, feldspathic, light-brownish-gray; fine to medium grained, slabby, cross-laminated, rare scattered clay pebbles; weathers pale yellowish brown.	
c. At about 155 ft.: Sandstone, light-brownish-gray; well indurated, fine grained to silt, slabby, cross-laminated to structureless, dark-red siltstone parting in middle of outcrop; weathers pale brown to grayish orange pink.	
b. At about 120 ft.: Sandstone, argillaceous, very light gray to white on fresh surface; fine grained, slabby, cross-laminated; about 40 percent white clay derived from altered feldspar; scattered limonite pseudomorphs after pyrite; weathers pale yellowish brown to very pale orange.	
a. At about 11 ft.: Sandstone, argillaceous, very light gray; fine to medium grained, slabby, cross-laminated; about 30 percent clay derived from feldspar; weathered surfaces strongly limonite stained.	
Total middle member	180

	Thickness (feet)
Dripping Spring Quartzite—Continued	
Barnes Conglomerate Member:	
1. Conglomerate, grayish-pink, massive, well-indurated; weathers moderate orange pink; forms ledge. Matrix: Sandstone, arkosic, grayish-pink; well indurated, medium coarse to very coarse grained, massive, structureless. Stones: 20 percent cobbles, 55 percent well-rounded pebbles; 70 percent spheroids; 25 percent disks; 5 percent blades and rollers composed of quartzite, vein quartz, and sparse red jasper	19
Total Barnes Conglomerate Member	19
Total Dripping Spring Quartzite	556

HAIGLER CREEK SECTION

Along bottom and northwest wall of Haigler Creek Canyon about 1–2 miles upstream from Fisherman Point on Globe-Payson road

	Thickness (feet)
Mescal Limestone:	
17. Breccia	Not measured
Dripping Spring Quartzite:	
Upper member:	
White unit:	
16. Siltstone, argillaceous, light-olive-gray to moderate-orange-pink; moderately indurated, clay to very fine grained, largely silt; flaggy and slabby, very thin bedded to structureless; weathers pale yellowish brown to moderate reddish orange; forms 25° slope	31
Buff unit, including white quartzite marker:	
15. Orthoquartzite, light-gray; medium grained, cross-laminated, slabby; weathers pale yellowish brown and light gray; forms ledge	3
14. Sandstone, arkosic, grayish-orange-pink to light-olive-gray; well indurated, medium to fine grained; flaggy to slabby, largely cross-laminated; weathers pale yellowish brown to pale reddish brown; forms 30° slope with ledges	15
13. Siltstone, arenaceous and argillaceous, grayish-orange to light-olive-gray; moderately, indurated; silt with clay and very fine grained sand; platy to flaggy, locally slabby; laminated and very thin bedded; weathers pale grayish orange to light olive gray; forms 30° slope	19
12. Sandstone, arkosic, grayish-orange; well-indurated, slabby to blocky, cross-laminated; weathers moderate reddish orange; forms cliff	16

	Thickness (feet)
Dripping Spring Quartzite—Continued	
Upper member—Continued	
Buff unit, including white quartzite marker—Continued	
11. Sandstone, arkosic, grayish-orange to grayish-orange-pink; well indurated, very fine grained; slabby, laminated and very thin bedded, locally cross-laminated; mud cracks; spotted rock above 30 ft; weathers grayish orange to light brown with dark-gray surficial stain; forms cliff in lower 30 ft or more; slopes and ledges above	49
Total buff unit	102
Gray unit:	
Black facies:	
10. Siltstone, micaceous at base, pyritiferous, dark- and light olive-gray; well indurated, flaggy, laminated and very thin bedded; stylolites and crumpled mud cracks common; graded bedding; weathers dark to medium dark gray, grayish-red hematite stain; forms smooth cliffs and steep slopes	44
Barren quartzite:	
9. Orthoquartzite, very light gray; medium and coarse grained, laminated and cross-laminated, slabby, lenticular; weathers pale red and very light gray; limonite stained; forms ledge	1
Gray facies and gray sandstone undifferentiated:	
8. Siltstone, arenaceous, limonitic; well indurated, silty to fine-grained, laminated to very thin-bedded, platy; basal 6–8 ft dark- to medium-gray siltstone; remainder is grayish-yellow and grayish-orange arenaceous siltstone; weathers medium gray and grayish orange; forms ledges	22
7. Conglomerate, mud plates in silty matrix; grades into overlying unit	0.5
6. Sandstone, feldspathic and sparsely micaceous, grayish-orange and grayish-orange pink; well indurated to quartzitic, fine grained to silt; flaggy to slabby, thinly laminated to very thin bedded; interstratified lighter colored and coarser grained quartzites with darker colored, more feldspathic, finer grained sandstones; weathers grayish orange and grayish orange pink; forms ledges	13
5. Conglomerate, consists of 40 percent angular pebbles of underlying unit and 60 percent pebbles, granules, and coarse-grained sand of vein quartz, quartzite, and siltstone; grades into overlying unit	0.5
Total upper member	214.0

Dripping Spring Quartzite—Continued

Not correlatable:

	Thickness (feet)
4. Sandstone, silty, pale-yellowish-brown to pale-red; well indurated, very fine grained to silt, slabby and flaggy, laminated and very thin bedded, ripple marks rare; weathers grayish orange pink to moderate reddish orange; forms ledges and slopes	29
3. Sandstone, arkosic, medium-gray; well indurated, very fine grained ranging from silt to fine grained; largely massive to slabby, laminated and very thin bedded; weathers light gray to grayish orange; forms cliff	49
2. Siltstone, dark-, medium-light-, and greenish-gray; well indurated, slabby and flaggy, laminated and very thin bedded; mud cracks; rare thin mud plate conglomerate beds; slabby 3-ft-thick bed of very fine and fine-grained arkosic quartzite at about 12 ft; weathers dark gray and greenish gray to pale red and grayish pink; forms ledges and cliffs	16
1. Conglomerate and interstratified conglomeratic sandstone and orthoquartzite, brownish-gray to grayish-red-purple; massive to blocky; forms ledges and cliffs. Matrix and interstratified units: Sandstone and orthoquartzite, brownish-gray to grayish-red-purple; well indurated to quartzitic, largely fine grained but some medium grained; massive to blocky, very thinly crossbedded and cross-laminated; weathers grayish pink to pale red and light olive gray. Stones: Less than 5 percent boulders, 50–60 percent cobbles, 15 percent pebbles, 5–10 percent granules, and 10–25 percent matrix; spheroids and a few disks; subangular, composed of quartzite and conglomerate with pebbles of quartzite, vein quartz, and moderate-reddish-brown jasper	47
Total not correlatable	141
Total Dripping Spring Quartzite	355

NATANES SECTION (IN 3 PARTS)

Part 1.—In a small canyon 200–300 yards northeast of a sharp turn in the road that is about 4.3 miles north of Casadore Spring and 2.3 miles north of the Metate asbestos mine road.

Mescal Limestone:

	Thickness (feet)
7. Sandstone, feldspathic to orthoquartzite, moderate-orange-pink to pale-red; fine-grained matrix with 20 percent coarse quartz grains and 5 percent very coarse feldspar grains; poorly sorted, massive to blocky, cross-laminated; weathers light brown to moderate red; forms cliff	9

Dripping Spring Quartzite:

	Thickness (feet)
Upper member:	
Buff unit:	
6. Siltstone, arenaceous, moderate-red to reddish-orange; well indurated, flaggy and slabby, laminated to thin-bedded; stylolites; weathers moderate orange pink to reddish orange; forms ledges and slopes	49
Buff(?) unit:	
5. Covered slope with no outcrop	64
Gray unit:	
Black facies:	
4. Siltstone, arenaceous, moderate-red to reddish-orange; well indurated; flaggy and slabby, laminated to thin bedded and cross-laminated in more arenaceous beds; stylolites, graded bedding, a few thin beds of cross-laminated medium-grained orthoquartzite in upper 30 ft of unit; weathers moderate orange pink to reddish orange; forms ledges and slopes	96
Gray sandstone:	
3. Sandstone, arkosic, limonitic, pale-brown to moderate orange-pink; well indurated, very fine and fine grained; slabby, cross-laminated; weathers light brown; forms ledge	5
Gray facies:	
2. Siltstone, scarce mica, pale-brown; well indurated, flaggy and slabby, laminated and very thin bedded; shrinkage cracks; weathers light brown; forms slope	19
Red unit and gray facies of the gray unit, incomplete:	
1. Covered except for small isolated outcrop at bottom; outcrop is interstratified sandstone and shale typical of the red unit	65
Total incomplete upper member	298

Part 2.—About one-fourth mile west of road from San Carlos to Hilltop; about 4 miles by road north of Casadore Spring and a mile north of the Metate mine road

Dripping Spring Quartzite, incomplete at top and base:

	Thickness (feet)
Upper member:	
Red unit (incomplete):	
7. Sandstone and siltstone, interstratified; Sandstone is arkosic, grayish red, well indurated, very fine grained, slabby, weathers pale reddish brown; siltstone is micaceous, slabby, laminated, weathers dark gray to brownish black; forms ledges	18

	Thickness (feet)
Dripping Spring Quartzite, incomplete at top and base—Continued	
Upper member—Continued	
Red unit (incomplete)—Continued	
6. Shale and sandstone, interstratified, flaggy and slabby. Shale is micaceous, medium dark gray to brownish black, moderately indurated, platy, laminated; shrinkage cracks; mud-plate conglomerate lenses common; weathers medium dark gray to brownish black; forms slope	47
Total incomplete upper member	65
Middle member:	
5. Orthoquartzite, vitreous, grayish-orange-pink; quartzitic, fine to medium grained, slabby and blocky, cross-laminated; cosets commonly capped by very fine grained to silty, graded, moderate-reddish-orange strata ½–6 in. thick; weathers pinkish to very light gray; forms ledges and cliffs	142
4. Orthoquartzite, limonitic, locally feldspathic, pale-red, medium grained, well indurated to quartzitic, blocky and massive, cross-laminated and very thinly crossbedded; weathers light brown to grayish orange pink; forms cliffs and ledges	35
3. Sandstone, arkosic, pale-yellowish-brown to moderate-reddish-orange; well indurated, fine to coarse grained, slabby and blocky, cross-laminated, laminated, and very thin bedded; scarce, scattered pebbles; scarce ripple marks; alternating blocky, coarse-grained sandstone and fine-grained sandstone; weathers grayish orange pink to moderate brown; forms ledges	11
2. Sandstone, conglomeratic, arkosic and feldspathic, dusky-yellow to pale-yellowish-brown; poorly to moderately indurated owing to weathered feldspars; fine to very coarse grained, largely coarse grained; moderately sorted, slabby to massive, cross-laminated to very thinly crossbedded and structureless, some cosets topped by very thin layer of reddish-orange siltstone; weathers grayish orange pink to moderate brown; forms ledges and slopes. Stones: less than 15 percent spheroidal quartzite, vein quartz, and, rarely, feldspar pebbles; 5–10 percent feldspar and vein quartz granules; quartzite and quartz is well rounded; feldspar is subangular; conglomeratic sandstones interstratified in sandstones	35
Total incomplete middle member	223

Part 3.—South flank of unnamed hill on the east side of Sycamore Creek north of the confluence of Bear Canyon. Probably in sec. 5 or 6, T. 3 N., R. 18 E.

	Thickness (feet)
Dripping Spring Quartzite, incomplete at top:	
Middle member:	
5. Sandstone, arkosic, grayish-pink to moderate-reddish-orange; moderately indurated to quartzitic, medium and fine grained, massive to blocky, cross-laminated; weathered surfaces casehardened by silica cement; abundant pockmarks about 1 in. across on weathered surfaces; weathers moderate to grayish orange pink; forms ledges to top of outcrop	49
4. Sandstone, conglomeratic in part, arkosic to orthoquartzite, light-brown to grayish-orange-pink; well indurated to quartzitic, medium to very coarse grained, largely coarse grained; massive, cross-laminated and very thinly crossbedded; tops of cosets commonly capped by 1 in. of moderate reddish-orange siltstone or very fine grained quartzite; ranges from 70 percent quartz at base to about 95 percent quartz at top; as much as 10 percent small quartz and feldspar pebbles and granules; weathers moderate orange pink and reddish orange near base to grayish orange pink near top; forms cliff	78
3. Sandstone, conglomeratic, arkosic, grayish-orange-pink; fine to coarse grained, moderately to poorly sorted; blocky and massive, cross-laminated, both cross-laminae and cosets are graded; shrinkage cracks in very fine grained graded layers about ¼ in. thick that cap many of the cosets; basal 10 ft contains as much as 40 percent pebbles composed of pinkish feldspar, quartzite, and vein quartz; weathers moderate reddish orange; forms cliff	27
2. Sandstone and siltstone, interstratified; forms slope. Sandstone: Arkosic, pale-red; well indurated, fine to medium grained, flaggy and slabby, cross-laminated; weathers light red. Siltstone: Argillaceous, hematitic, grayish-red; flaggy and slabby, laminated; contains scattered medium-grained quartz grains; weathers grayish red	15
Total incomplete middle member	169

	Thickness (feet)
Dripping Spring Quartzite, incomplete at top—Continued	
Barnes Conglomerate Member:	
1. Conglomerate, moderate-orange-pink; blocky to massive, fills paleochannels 2 ft deep in Pioneer formation; fractures filled with specularite; well indurated; forms cliff. Matrix: Sandstone, arkosic, moderate-orange-pink; well indurated, largely coarse grained; blocky and massive, very thin to very thick bedded; weathers moderate orange pink to moderate reddish orange. Stones: 5 percent cobbles, 55 percent pebbles, 5 percent granules, 35 percent matrix; largely well rounded, less than 1 percent angular and subangular; 85 percent spheroids, 15 percent disks; composed of 65 percent quartzite, 30 percent vein quartz, 5 percent red jasper	6
Total Barnes Conglomerate Member	6

NOTE: Direct correlation between parts 1 and 2 is not possible because the top of part 2 is stratigraphically below the lowest continuous outcrop in part 1. Interval 1 of part 1, however, starts at an isolated outcrop of rocks similar to interval 6 of part 2. A tentative correlation has therefore been made using the top of the red unit as a reference plane. It is suggested that the top of the red unit is 5 ft above interval 7 in part 2 and is 39 ft above the bottom of interval 1 of part 1; the gray facies of the gray unit in part 1 is assumed to be 45 ft thick which is in the same order of magnitude as the nearest measured sections.

In like manner, direct correlation of parts 2 and 3 of the Natanes section is not possible; the distance between the two parts is relatively large and the exposures in the area are poor. The best available criterion is the conglomeratic nature of some of the sandstones. Therefore a tentative correlation is made from the top of interval 4 in part 3 to the top of interval 2 in part 2. Intervals 4 and 2 are both conglomeratic sandstones.

Thickness of the Dripping Spring Quartzite, based on tentative correlations among parts of the Natanes section, therefore, are:

	Feet
Upper member	329
Middle member	308
Barnes Conglomerate Member	6
Total Dripping Spring Quartzite	643

PIONEER SECTION (WEST OF ROAD)

In south-trending canyon 8,000 feet due west of Pioneer Stage Station, Ray quadrangle

	Thickness (feet)
14. Diabase	Not measured
Mescal Limestone:	
13. Sandstone, feldspathic to orthoquartzite, greenish-gray; poorly sorted, poorly indurated to quartzitic; averages medium grained; slabby, laminated and structureless; green color caused by chlorite(?); weathers greenish to medium light gray; forms ledge	13
Dripping Spring Quartzite:	
Upper member:	
Buff unit:	
12. Sandstone, arkosic to feldspathic, yellowish-gray to grayish-orange-pink; fine grained to silt, slabby and blocky, wispy cross-laminated to laminated; mud cracks abundant; graded laminae, abundant limonitic specks; weathers light brown to very pale orange; forms cliff	41
Gray unit:	
Black facies:	
11. Siltstone, medium dark to dark gray; well indurated, platy and flaggy to slabby near top; thinly laminated to very thin bedded; weathers medium dark gray with limonite surface stains; forms steep slope	99
Gray sandstone equivalent(?):	
10. Siltstone, arenaceous and argillaceous, grayish-orange; well-indurated, clay to very fine grained; graded laminae, flaggy to slabby, laminated, mud cracks, pale-red spots just above diabase; weathers moderate yellowish orange; forms ledges	23
9. Diabase sill and probable fault. Cuts out about 126 feet of gray unit.	
Red unit (incomplete at top?):	
8. Siltstone and sandstone, interstratified, forms cliff. Siltstone: Argillaceous and micaceous, dark-gray; well indurated, slabby, laminated, mud cracks and ripple marks; weathers brownish black. Sandstone: Arkosic to feldspathic, sulfides common, pale-red to medium-light-gray; well indurated to quartzitic, very fine to coarse grained, slabby, laminated and cross-laminated; weathers pale red to medium gray	29

Dripping Spring Quartzite—Continued

Upper member—Continued

Red unit (incomplete at top?)—Continued

	Thickness (feet)
7. Shale and sandstone lenses, interstratified, forms slope. Shale: Mottled very dusky red; micaceous, platy, laminated and thinly laminated; mud cracks common, ripple marks rare; few scattered very thin mud-plate conglomerate beds; weathers very dusky red; forms slope. Sandstone: Arkosic, moderate-orange-pink; well indurated, very fine and fine grained; slabby and flaggy, laminated; weathers moderate pink; forms narrow ledges in slope	45
Total upper member (first of 2 incomplete sections)	235

Middle member:

	Thickness (feet)
6. Sandstone, arkosic to feldspathic, moderate-orange-pink, well indurated, very fine grained; slabby to blocky, cross-laminated to structureless; weathers moderate orange pink to grayish orange pink; forms ledges	20
5. Orthoquartzite, feldspathic, moderate-orange-pink to gray; well indurated to quartzitic, fine to coarse grained, largely medium grained; massive and blocky, laminated and cross-laminated, graded cosets; weathers pinkish gray; forms cliff	57
4. Sandstone, arkosic, pale-red; well indurated, fine grained with medium- and coarse-grained lenses; blocky to massive, laminated and cross-laminated, graded bedding; weathers light red; forms cliff	30
3. Sandstone and orthoquartzite, arkosic to feldspathic, pale-red and pale-reddish-brown to grayish-orange; well indurated to quartzitic, very fine to coarse grained, largely medium grained; slabby to massive, cross-laminated, contains interstratified units described below; weathers pale reddish brown to grayish orange pink; forms cliffs. Sandstone strata at intervals 17.6–18.6, 47.5–51.0, 58.3–60.9, and 68.9–70.4 ft: Micaceous and argillaceous, very dusky red, moderately to poorly indurated, fine-grained to clay-sized, poorly sorted, flaggy and platy, laminated and very thin bedded, locally ripple marked; weathers grayish red; forms protected slopes	75

	Thickness (feet)
Dripping Spring Quartzite—Continued	
Middle member—Continued	
2. Sandstone, conglomeratic, pale-red to grayish-orange-pink; blocky; forms cliff. Matrix: Sandstone, arkosic to feldspathic, pale-red to grayish-orange-pink; well indurated, medium to coarse grained; blocky, cross-laminated and structureless; weathers pale red to grayish orange pink. Stones: Pebbles, spheroids, well-rounded except for subangular shale fragments; composed of 30 percent quartzite, 40 percent vein quartz, 25 percent siliceous shale and feldspar, and 5 percent red jasper	11
Total middle member	193
Barnes Conglomerate Member:	
1. Conglomerate, light-bluish-gray; massive, forms cliff. Matrix: Sandstone, feldspathic, light-bluish-gray; coarse to very coarse grained, poorly sorted; massive, structureless; weathers to mottled medium light gray. Stones: 20–25 percent cobbles, 60 percent pebbles, 15–20 percent granules and matrix; spheroids and sparse disks; well rounded, composed largely of quartzite and about 35 percent vein quartz	8
Total Barnes Conglomerate Member	8
Total incomplete Dripping Spring Quartzite	436

PIONEER SECTION (EAST OF ROAD)

South wall of Pioneer Creek 4,500 feet southeast of Pioneer Stage Station, Ray quadrangle

	Thickness (feet)
Mescal Limestone:	
8. Sandstone, quartzitic, greenish-gray; fine to coarse grained, poorly sorted; weathers to grayish red; forms ledge	3
Dripping Spring Quartzite:	
Upper member:	
Buff unit:	
7. Sandstone, argillaceous, largely feldspathic, grayish-orange to light-gray; very fine to fine grained, some silt and clay; slabby to flaggy, very thin bedded to thinly laminated, well indurated; weathers grayish orange; forms ledges and steep slopes	41

Dripping Spring Quartzite—Continued

Upper member—Continued

Gray unit:

	Thickness (feet)
Black facies:	
6. Siltstone, arkosic, dark-gray near bottom to light-gray near top; slabby to flaggy, thinly laminated and laminated, well indurated, mud cracks near top; weathers dusky red and brownish black to grayish orange and grayish orange pink; limonite stained; forms steep slope with rounded ledges	73
5. Siltstone, arkosic, interstratified feldspathic orthoquartzite, grayish-orange and yellowish-gray; orthoquartzite is medium grained; siltstone is flaggy, thinly laminated and laminated, well indurated and quartzitic, crumpled mud cracks, "wavy" stratification, small pseudochannels (?); weathers grayish orange and moderate brown; forms slope	34
Gray sandstone (?) and possibly barren quartzite:	
4. Sandstones, feldspathic, pinkish-gray; blocky, laminated to thin bedded and cross-laminated, quartzitic; weathers grayish orange; forms ledge	11
Gray facies:	
3. Siltstone, arkosic, yellowish-gray; flaggy to slabby, laminated to thin bedded, well indurated; mud cracks near bottom; weathers pale to dark yellowish brown; forms slope	127
Red unit, incomplete at bottom:	
2. Siltstone, interstratified sandstone, arkosic grading upward to feldspathic; sandstone layers more abundant upward; 7-ft sandstone layer at top; forms cliff. Siltstone: Arkosic, brownish and light brownish-gray to pale yellowish-brown, silt to very fine grained locally; blocky, slabby, laminated to thin bedded, well indurated; weathers pale to dark yellowish brown and pale brown. Sandstone: Feldspathic, light olive-gray to medium-gray; fine to medium grained, massive to blocky, laminated to thin bedded, quartzitic; weathers light olive gray and brownish gray	44
Total upper member (incomplete)	330

1. Diabase sill.

NOTE: The thickness of the upper member is calculated on the basis of a tentative correlation of the two Pioneer sections. During reconnaissance study of a partial section several miles from Pioneer Stage Station, the red unit was found to comprise two parts, the upper of which was about 40 ft thick. On this premise, it is assumed that about 126 ft of the western section was cut out where the section was intruded by a diabase sill and it is inferred that the red unit was about 83 ft thick in both sections prior to diabase intrusion. Thickness data suggested by this correlation are.

	Thickness (feet)
Upper member (east of road)	369
Middle member (west of road)	193
Barnes Conglomerate Member (west of road)	8
Total Dripping Spring Quartzite	570

POTTS CANYON SECTION

W½ sec. 21, T. 1 S., R. 12 E., in Whitford Canyon (locally called Potts Canyon) on south side of canyon about 1,000 feet southwest of Prudential mine, Picketpost Mountain quadrangle

	Thickness (feet)
Mescal Limestone:	
19. Mudstone, contains poorly sorted quartz grains; iron stained, forms ledge	Not measured
Dripping Spring Quartzite:	
Upper member:	
White unit:	
18. Siltstone, arenaceous, medium-light-gray; silt to very fine grained, slabby laminated; weathers grayish orange pink; forms slope	3
Buff unit, including white quartzite marker:	
17. Orthoquartzite, feldspathic and argillaceous, medium-light-gray; very fine grained to silt; well indurated, porcelaneous fracture, slabby, laminated to thin-bedded, capped by unit 2.5 ft thick of very fine grained, lenticular orthoquartzite; weathers grayish orange pink; forms slope with ledges	41
16. Sandstone, arkosic, grayish-pink; well indurated, fine to medium grained; blocky at base, slabby at top, cross-laminated; weathers light gray with limonite stain; forms ledges	9
Gray unit:	
Black facies, may include some buff unit at top:	
15. Siltstone, arenaceous, medium-dark-gray to light-gray; well indurated, flaggy and slabby, laminated and very thin bedded; weathers pale reddish orange to pale yellowish brown; form 14° slope	118
Gray sandstone and barren quartzite:	
14. Sandstone and orthoquartzite, feldspathic at base, grayish-orange-pink; fine to medium grained, well indurated to quartzitic, better cemented near top; slabby to massive, largely blocky; laminated to very thin bedded, some mud cracks and stylolites; weathers very light gray with some limonite stain; forms cliffs and ledges	61

	Thickness (feet)
Dripping Spring Quartzite—Continued	
Upper member—Continued	
Gray unit—Continued	
Gray facies:	
13. Shale, strongly bleached to medium light gray and olive gray; poorly indurated, shaly; laminated and thinly laminated; weathers grayish orange pink to grayish red; forms 18° slope	68
12. Sandstone and orthoquartzite, feldspathic, light-olive-gray to olive-gray; moderately indurated to quartzitic, very fine to fine grained; slabby, laminated, few mud cracks; weathers grayish red to moderate orange pink; forms ledges	17
Red unit:	
11. Siltstone, argillaceous and micaceous, with interstratified impure sandstone and quartzite strata; grayish red to pale yellowish brown; poorly to moderately indurated, with indurated very fine grained sandstone and quartzite lenses; platy to flaggy, laminated; weathers very dusky red to light brown; forms slope; 44-ft diabase sill 37 ft above base of interval	57
10. Sandstone, argillaceous, micaceous, pale-red; very fine and fine grained with silt and clay; platy to slabby, largely flaggy; laminated with interstratified thin structureless orthoquartzite strata; local ripple marks; weathers moderate reddish orange; forms slope	23
Total upper member	397
Middle member:	
9. Orthoquartzite, locally feldspathic, moderate-orange-pink; medium grained, well sorted, massive, cross-laminated; weathers moderate orange pink to medium light gray; forms cliff	25
8. Orthoquartzite, feldspathic, grayish- to pale-red; fine grained, slabby to massive, largely blocky; very thinly crossbedded and cross-laminated; weathers grayish to pale red; forms cliff	34
7. Orthoquartzite and sandstone, feldspathic, moderate-orange-pink; fine to medium grained, massive, very thinly crossbedded and cross-laminated; weathers light brown to grayish pink; forms cliff	48
6. Sandstone, arkosic, moderate-reddish-orange; moderately indurated, very fine to fine grained; massive, cross-laminated and very thin bedded; weathers moderate red; forms ledges	9

	Thickness (feet)
Dripping Spring Quartzite—Continued	
Middle member—Continued	
5. Sandstone, arkosic to feldspathic, grayish-red to grayish-orange-pink depending on quartz content; well indurated to quartzitic; fine to medium grained, massive, cross-laminated; weathers grayish red to grayish pink; forms cliff	30
4. Sandstone, arkosic, grayish-red to moderate orange-pink; moderately to well indurated, fine to coarse grained, largely medium grained; largely massive, some blocky; cross-laminated, some lenses identical to underlying unit; weathers grayish red to moderate pink; forms cliff	32
3. Sandstone, arkosic, grayish-red with bleached grayish-pink spots; moderately to poorly indurated, medium grained; flaggy, very thin bedded and laminated; weathers grayish red with grayish orange-pink spots; supported by enclosing cliffs	3
2. Sandstone, arkosic, grayish-orange-pink; moderately to well indurated, fine to coarse grained, poorly sorted, massive and slabby, laminated and cross-laminated; few scattered conglomerate lenses consisting of quartzite, vein quartz, and siliceous mud-plate pebbles; weathers grayish orange pink; forms cliff	19
Total middle member	200
Barnes Conglomerate Member:	
1. Conglomerate, pale-red; well indurated; massive, locally cross-stratified; forms cliff. Matrix: Sandstone, arkosic, pale-red; well indurated, fine to very coarse grained, poorly sorted; weathers to pale red. Stones: 75 percent pebbles, 25 percent cobbles; well-rounded; 80 percent spheroid, 20 percent disk; largely quartzite, white vein quartz common; red jasper scarce	8
Total Barnes Conglomerate Member	8
Total Dripping Spring Quartzite	605

RED BLUFF SECTION

Barnes Conglomerate Member and middle member in Hog Canyon, E½ sec. 25, T. 5 N., R. 13 E.

Upper member on west side of canyon in the E½ sec. 32, T. 5 N., R. 14 E., Rockinstraw Mountain quadrangle.

	Thickness (feet)
Mescal Limestone:	
8. Sandstone, argillaceous, poorly sorted	Not measured

	Thickness (feet)
Dripping Spring Quartzite:	
Upper member:	
White unit:	
7. Sandstone, argillaceous, light to very light gray; very fine grained to silt, moderately sorted; slabby, laminated, stylolites common; limonitic pock marks at top; scarce preconsolidation slump structures; weathers very pale orange to grayish orange with dark-yellowish-orange iron stain; forms 15° slope	11
Buff unit, including white quartzite marker:	
6. Orthoquartzite, feldspathic at base, yellowish-gray; fine grained at base, coarse grained at top; slabby to blocky, cross-laminated and laminated; weathers grayish orange; locally pock marked; forms cliff	14
5. Sandstone, arkosic, grayish-orange to light-bluish-gray and yellow-gray; well indurated to quartzitic, fine grained to silt with interstratified thin medium-grained strata; flaggy to blocky, laminated and cross-laminated; local small scours; few slump and compaction structures; stylolites common; weathers very pale to grayish orange with dark-yellowish-orange iron stain; forms cliff	96
Gray unit:	
Black facies:	
4. Siltstone, dark- to medium-gray, some light-gray laminae; well indurated, platy to slabby, laminated; crumpled mud cracks common; stylolites common; weathers medium gray to grayish red; forms smooth to rubbly 30° slope	101
Gray sandstone and barren quartzite:	
3. Sandstone and orthoquartzite, olive-gray; silt and very fine grained at base to fine grained at top; moderately indurated at base to quartzitic at top; arkosic at base to orthoquartzite at top; massive to blocky, thick bedded to laminated, slump structures common at base; weathers pale red; forms cliff	17
Gray facies:	
2. Siltstone, arenaceous, very pale orange to pale-yellowish-brown; well indurated, flaggy to blocky, thin-bedded to thinly laminated with sparse cross-lamination; minor preconsolidation slump structures; stylolites common, ripple marks rare; pseudochannels common; weathers grayish orange with moderate-reddish-brown iron-stained surfaces; forms cliff in lower half; forms 38° ledgy slope in upper half	62
Red(?) unit:	
1. Siltstone, arenaceous, very light gray to yellowish-gray; well indurated, massive, thin-bedded to laminated; ripple marks rare; pseudochannels common; weathers yellowish gray; forms cliff	36
Total upper member	337

Dripping Spring Quartzite—Continued	*Thickness (feet)*
Middle member:	
5. Orthoquartzite, largely feldspathic, pale-red to pinkish-gray; medium and fine grained, well sorted, massive to blocky, very thin bedded (crossbedded?); rare pock marks; weathers light brownish gray; forms ledges	91
4. Sandstone, feldspathic, pale-red to moderate-orange-pink; well-indurated, alternating very fine to medium grained strata; well sorted, blocky, very thin bedded to cross-laminated, rare ripple marks at tops of graded sets and cosets; pock marked in basal 4 feet; weathers pale red; forms ledges and cliffs	67
3. Sandstone, arkosic, moderate- to pale-red; well indurated, very fine grained at base with fine- and medium-grained strata near top; well sorted, blocky to massive, thin and very thin bedded, crossbedded, ripple marked on top of mudstone splits and graded sets; weathers moderate to pale red with local limonite stain; forms cliff	165
2. Conglomerate strata alternating with arkosic sandstone strata, moderate-pink; massive, well indurated; forms cliff. Matrix and arkosic sandstone: Sandstone, arkosic, moderate-pink; coarse and medium grained, moderately sorted; thin to very thin bedded, cross-stratified; weathers light red. Stones: As much as 50 percent vein quartz and quartzite pebbles and granules; well-rounded to subrounded, spheroidal	32
Total middle member	355
Barnes Conglomerate Member:	
1. Conglomerate, moderate-red; massive, poorly to well indurated, abundant specularite cement and joint filling; forms cliff. Matrix: Sandstone, arkosic, moderate-red; very fine to very coarse grained, poorly sorted, very thin bedded; weathers grayish red. Stones: Minor quartzite cobbles; as much as 60 percent white vein quartz and quartzite pebbles; 5–50 percent feldspar and quartz pebbles and granules; well rounded, mostly spheroidal, some disks	4
Total Barnes Conglomerate Member	4
Total Dripping Spring Quartzite	696

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ROOSEVELT DAM SECTION

Along road and in canyon about 1000–2000 feet south of Roosevelt Dam, Roosevelt quadrangle

	Thickness (feet)
Mescal Limestone:	
15. Sandstone, argillaceous, poorly sorted, massive, quartzitic in part	Not measured
Dripping Spring Quartzite:	
Upper member:	
White unit:	
14. Siltstone, argillaceous, moderate-reddish-orange; well indurated, flaggy, laminated; forms protected slope	3
Buff unit, including white quartzite marker:	
13. Sandstone, silty, abundant orthoquartzite lenses, medium-light-gray; fine grained to silt, medium-grained orthoquartzite; slabby, laminated to structureless; orthoquartzite lenses more abundant upward; weathers medium light gray with moderate-reddish-orange limonite along stratification planes; forms ledge	7
12. Sandstone, arkosic, moderate-yellowish-brown; well indurated, fine grained to silt, a few medium-grained lenses in upper 100 ft; graded bedding, flaggy to massive, largely blocky; laminated to very thin bedded and some cross-lamination; mud cracks and stylolites common; weathers moderate orange pink with grayish red bands along stylolites; forms cliff	161
Gray unit:	
Black facies:	
11. Shale, silty, grayish-black to dark-gray; moderately to well indurated; platy, some flaggy and slabby, laminated and thinly laminated; mud cracks scarce; weathers grayish brown to yellowish gray with limonite stain; forms 35° slope	65
Gray sandstone and barren quartzite (?):	
10. Sandstone, feldspathic and hematitic, pale-reddish-brown; well indurated, very fine grained to silt; blocky to flaggy, cross-laminated; weathers moderate red, some hematite stain; forms ledge	6
Gray facies:	
9. Shale with a few sandstone lenses, dark-gray to dusky-yellow; moderately indurated, platy except for slabby sandstone lenses in lower 15 ft; weathers yellowish gray to very light gray and moderate red; forms 30° slope	60
Red unit:	
8. Sandstone, feldspathic and micaceous, pale-red; well indurated, fine to very fine grained; slabby to blocky, has platy partings; laminated, weathers grayish orange; forms slope with cliffs locally	11

Dripping Spring Quartzite—Continued

Upper member—Continued

Red unit—Continued

	Thickness (feet)
7. Sandstone with shaly partings; micaceous and arkosic, pale-reddish-brown sandstone and blackish-red to dark-gray shale; well indurated sandstone; moderately indurated shale; sandstone is fine grained, shale is silty; flaggy with local slabby beds and platy partings; cross-laminated sandstone; sandstone weathers pale reddish brown; shale weathers very dusky red purple; forms slope and local cliffs	9
Total upper member	322
Middle member:	
6. Orthoquartzite, pale-red; well indurated to quartzitic, fine- to medium-grained; blocky, cross-laminated; contains interstratified thin-bedded sandstone partings; weathers grayish orange; forms cliffs and steep ledgy slopes	27
5. Sandstone, hematitic and argillaceous, moderate-red to dark-reddish-brown; moderately indurated, medium-grained to clay, poorly sorted; flaggy to slabby with shaly partings; laminated; weathers pale red; forms slope	4
4. Orthoquartzite and feldspathic sandstone, grayish-pink to grayish-purple; well indurated to quartzitic, largely medium-grained, some fine grained; massive to blocky; cross-laminated and very thinly crossbedded; weathers pale brown to grayish orange; forms ledges and slope	62
3. Sandstone, arkosic and feldspathic, grayish-red to grayish-orange-pink and light-brownish-gray; well indurated, medium to very fine grained; blocky to flaggy, largely slabby; cross-laminated; and laminated; alternating medium-grained feldspathic sandstone and fine to very fine grained arkosic sandstone cosets; weathers to mottled and streaked grayish orange pink and light brownish gray; forms steep slope	85
2. Sandstone, arkosic, moderate-orange-pink, locally mottled with pale red purple; well indurated, interstratified coarse- to medium-grained and medium to very fine grained strata, sorting best near top; massive to blocky, cross-laminated, laminated at tops of cosets; weathers moderate reddish orange; cliff in lower part, ledges above	191
Total middle member	369

	Thickness (feet)
Dripping Spring Quartzite—Continued	
Barnes Conglomerate Member:	
1. Conglomerate, moderate-orange-pink; massive, well indurated; forms cliff. Matrix: Sandstone, arkosic, grayish purple to moderate-orange-pink; medium grained, massive, cross-laminated; some lenses are nonconglomeratic sandstone; weathers grayish red. Stones: Largely pebbles; a few cobbles and granules; constitute 50–60 percent of rock; well rounded, spheroids; 70 percent composed of quartzite, 30 percent vein quartz	17
Total Barnes Conglomerate Member	17
Total Dripping Spring Quartzite	708

SNAKEBIT SECTION (UPPER MEMBER ONLY)

North wall of westward-trending tributary to Ash Creek about 2.6 miles east of Picacho Colorado, Blue House Mountain quadrangle

	Thickness (feet)
Mescal Limestone:	
9. Sandstone, argillaceous, pale-olive-gray; medium grained to silt, poorly sorted	Not measured
Dripping Spring Quartzite:	
Upper member:	
White unit:	
8. Sandstone, silty, very light gray; very fine grained to silt, moderately to well indurated, flaggy and slabby, laminated and very thin bedded; weathers light gray and grayish orange pink with iron stain; forms slope	13
Buff unit, including white quartzite marker:	
7. Orthoquartzite, feldspathic to pure, pinkish-gray to white; fine and medium grained; massive, cross-laminated to structureless; weathers grayish orange pink; forms cliff	6
6. Sandstone, arkosic, very fine grained and silt; well indurated, massive to flaggy, laminated and cross-laminated, metamorphic spots, stylolites; weathers light gray to white; forms cliff	43
Gray unit:	
Black facies:	
5. Siltstone, dark-gray with medium-light-gray in upper 20 ft; well indurated; massive to platy, thinly laminated to thin bedded; pyrite-filled stylolites abundant; mud cracks; uranium-bearing interval at about 12 ft; weathers dark to medium light gray with much limonite stain; forms 35° slope with smooth surfaces	107

Dripping Spring Quartzite—Continued
Upper member—Continued
Gray unit—Continued

Thickness (feet)

Gray sandstone and barren quartzite:

4. Sandstone and orthoquartzite, feldspathic and arkosic, silty, very light gray to grayish-pink; silt to medium grained, largely very fine and fine grained; well indurated and quartzitic, flaggy to slabby, some blocky; thin bedded to laminated, cross-stratified; fine to medium-grained lenses more abundant upward; preconsolidation distortion features in 5-foot-thick sandstone at base; weathers grayish pink and white; bleached, forms cliff ----- 38

Gray facies:

3. Siltstone, arenaceous, pinkish-gray and grayish-pink; silt and some very fine grained; well indurated, flaggy to blocky, laminated and very thin bedded; weathers grayish pink; bleached; forms cliff ----- 46

Red unit:

2. Sandstone, hematitic, arkosic, micaceous, moderate-red to moderate-reddish-orange; silty partings less common than in interval 1; silt to fine grained, well indurated, flaggy and slabby, laminated; weathers moderate to grayish orange pink; forms cliff ----- 14

1. Sandstone, hematitic, arkosic, micaceous, moderate-pink to moderate-reddish-orange; has silty and shaly partings; clay to very fine and fine grained, well indurated, flaggy, laminated; mud cracks; weathers to moderate and grayish orange pink with olive-gray partings; forms cliff ----- 20

Total upper member ----- 287

WALNUT CREEK SECTION (UPPER MEMBER ONLY)

Sec. 25, T. 8 N., R. 14 E., in Walnut Creek, a tributary to Cherry Creek, just north of McFadden Peak quadrangle

Thickness (feet)

Mescal Limestone:

11. Chert breccia ----- Not measured

Dripping Spring Quartzite:
Upper member:
White unit and buff unit, including white quartzite marker:

10. Orthoquartzite, pinkish-gray, quartzitic; fine grained to silt, well sorted, flaggy to blocky, cross-laminated; becomes darker, more feldspathic, thinner bedded, and more cherty appearing toward top of unit; forms cliff ----- 41

	Thickness (feet)
Dripping Spring Quartzite—Continued	
Upper member—Continued	
White unit and buff unit, including white quartzite marker—Continued	
9. Sandstone, arkosic, pinkish- to light-gray; well indurated, very fine to fine grained; flaggy to slabby, laminated and cross-laminated; weathers pale reddish brown and pale red with darker stains; forms steep ledgy slope	50
8. Sandstone, arkosic, pale-yellowish-brown; well indurated, fine and very fine grained; platy to slabby, laminated and cross-laminated to structureless; succession of resistant lenses with less resistant partings; weathers grayish orange with grayish-red and dark-gray stain; forms steep ledgy slope	55
Gray unit:	
Black facies:	
7. Siltstone with interlensed sandstones, forms steep slope with ledges. Siltstone: Dark- to light-gray; well indurated, platy to slabby, laminated; weathers gray to moderate red. Sandstone lenses: Medium-gray; well-indurated (novaculitic), very fine grained; slabby, seems to be structureless; weathers moderate to pale red	30
6. Siltstone, sparsely micaceous, dark- to medium-gray; well indurated; platy to slabby, laminated; contains a few lighter colored; fine- and medium-grained arkosic sandstone lenses; weathers grayish orange pink with moderate-orange-pink to moderate-reddish-brown stains; forms steep slope with ledges	32
Gray sandstone and barren quartzite:	
5. Sandstone, arkosic; well indurated to quartzitic, very fine to fine grained; flaggy to massive; contains series of resistant lenticular sandstones separated by less-resistant sandstone splits; contains a paleochannel about 30 ft deep and more than 200 ft across, filled with similar rocks; weathers yellowish gray to pale yellowish brown and pale red; forms cliffs and ledges	34
Gray facies:	
4. Siltstone and interstratified lenticular sandstones; many pseudochannels; ripple marks abundant; forms slopes and ledges. Siltstone: Rarely micaceous, dark- through light-gray to moderate-red; platy to flaggy, laminated. Sandstone: Arkosic pale-yellowish-brown; slabby, laminated and cross-laminated; forms the cores of pseudochannels	54

Dripping Spring Quartzite—Continued
Upper member—Continued
Gray unit—Continued
Gray facies—Continued

	Thickness (feet)
3. Orthoquartzite, feldspathic; well indurated to quartzitic, fine to very fine grained; thick bedded to cross laminated, ripple marked on local shaly partings; weathers grayish orange pink; forms ledge	4
Red unit:	
2. Sandstone, micaceous, silty; moderately to well indurated, fine grained to silt; platy to slabby, thinly laminated to very thin bedded and cross laminated, mud cracked locally; upper 3 ft is a silicified fissile siltstone; contains lenticular fine-grained sandstone strata; weathers brownish gray to grayish red; forms ledges	8
1. Sandstone, micaceous, silty; moderately to well indurated; slabby, blocky, and platy; very thin bedded and cross laminated; lenticular cross-laminated sandstones with shaly partings; weathers grayish red; forms ledges	8
Total upper member	316

WILSON CREEK SECTION (UPPER MEMBER ONLY)

E½ sec. 36, T. 8 N., R. 14 E., and W½ sec. 31, T. 8 N., R. 15 W., in bottom of Wilson Creek Canyon thence up north wall along mine tramway, McFadden Peak quadrangle

	Thickness (feet)
Mescal Limestone:	
7. Poorly sorted sandstone, argillaceous, dark-greenish-gray to pale-red; contains calcite-filled vugs; forms ledge	4
Dripping Spring Quartzite:	
Upper member:	
White unit:	
6. Siltstone, arenaceous, dark-gray to medium-light-gray; moderately to well indurated, silt to fine grained; slabby to flaggy, thinly laminated; weathers medium light gray to pale yellowish brown; forms ledgy slope	20
Buff unit, including white quartzite marker:	
5. Orthoquartzite, feldspathic, very light gray to pale-red, quartzitic; medium to coarse grained; slabby to blocky, laminated and thin bedded; weathers pale red to light gray; forms ledge	4

	Thickness (feet)
Dripping Spring Quartzite—Continued	
Upper member—Continued	
Buff unit, including white quartzite marker—Continued	
4. Sandstone, feldspathic, light- and light-brownish-gray, medium-dark-gray at top; contains silty partings; well indurated to quartzitic, medium grained to silt, largely very fine and fine grained; slabby and blocky with platy and flaggy partings; laminated and thinly laminated, cross-laminated and thinly cross-laminated, much cross-stratification; stylolites abundant; silty partings more abundant upward; sandstone strata, 3 to 4 ft thick, with preconsolidation distortion features at bottom and about 10 ft from top; weathers medium light gray and light gray and light brown; bleached; forms cliff	74
Gray unit:	
Black facies:	
3. Siltstone, arenaceous, dark- and yellowish-gray to pale-yellowish-brown; well indurated; platy to slabby, locally blocky, averages flaggy; thinly laminated to thin bedded, "wavy" bedding, sparse mud cracks; several layers ½ to 2 ft thick of medium to very fine grained feldspathic sandstone and orthoquartzite. Sandstone is wispy cross-laminated, with stylolites, crumpled mud cracks, limonite pseudomorphous after pyrite; uranium-bearing interval at 50 ft; weathers light and medium light gray to light and pale yellowish brown; forms cliffs and steep slopes	120
Barren quartzite:	
2. Orthoquartzite, lenticular with interstratified siltstone, very light gray, pinkish- and yellowish-gray, grayish-orange-pink; quartzitic, medium and fine grained, locally coarse grained; flaggy and slabby, thinly laminated to laminated and cross-laminated; clay-gall conglomerate locally at base; fucoidal markings on interstratified siltstone; limonite pseudomorphous after sulfide minerals (?); weathers to very light gray and grayish orange pink; forms rounded ledges	2
Gray facies and gray sandstone undifferentiated:	
1. Siltstone and sandstone, micaceous, very light gray to light-brownish-gray; well indurated to quartzitic, silt to fine grained; flaggy to blocky, laminated to thin bedded, wispy cross-lamination; sparse orthoquartzite lenses are abundantly cross-stratified; many stylolites; pock-marked strata; pseudochannels abundant; preconsolidation distortion features in fine-grained sandstone at about 10–12 ft; weathers medium and medium light gray to light brownish gray and grayish red; forms ledges and steep slopes	16
Total upper member	236

WORKMAN CREEK SECTION (UPPER MEMBER ONLY)

SW¼ sec. 30, T. 6 N., R. 14 E., on west side of ridge marking the Sierra Ancha Experiment Station boundary, McFadden Peak quadrangle

	Thickness (feet)
Mescal Limestone:	
9. Poorly sorted coarse quartz grains in a dolomitic white mudstone	Not measured
Dripping Spring Quartzite:	
Upper member:	
White unit:	
8. Siltstone, argillaceous, rarely arenaceous, very light gray and very pale orange; silt and clay with scarce very fine grained lenses; well indurated, novaculitic in upper 25 ft; flaggy to blocky, averages slabby; laminated and very thin bedded, rare wispy cross-lamination, generally flat and even stratification; fucoidal markings rare; basal 20 ft locally resembles black or gray facies but the color above is much lighter; weathers dark yellowish orange to moderate brown with some grayish-brown stain; forms ledges in lower part and cliff above	124
Buff unit, including white quartzite marker:	
7. Orthoquartzite, white to olive-gray and very light gray; quartzitic, coarse grained at top and very fine to coarse grained sets near base; slabby and blocky, cross-laminated, planar cross-stratified sets; scarce pock marks; limonite pseudomorphous after pyrite locally; weathers very light gray to light brown; forms ledge and locally cliff	9
6. Sandstone argillaceous to arkosic, and orthoquartzite; sandstone silty very light gray and yellowish-gray to white; silt to medium grained, average between very fine and fine grained, well indurated to quartzitic; slabby and blocky in lower third; slabby above; laminated and sparsely cross-laminated in lower third, laminated and cross-laminated to thin bedded above; generally well sorted but local poorly sorted lenses of medium-grained orthoquartzite; orthoquartzite lenses more abundant upward; stylolites abundant; spotted rock common in upper part; weathers very light and yellowish gray, stained moderate reddish orange, particularly in upper part; forms slopes with cliffs and ledges in lower third; forms ledgy slope above	76

Dripping Spring Quartzite—Continued
Upper member—Continued
Gray unit, incomplete:
Black facies:

	Thickness (feet)
5. Siltstone, arenaceous, arkosic, dark to very light gray, locally grayish-orange-pink; locally very fine grained, scarce fine-grained lenses, well indurated; flaggy and slabby, laminated to very thin bedded, locally thin bedded; crumpled mud cracks; weathers light brown and very pale orange with some dark yellowish orange; forms slope with hackly and smoothly rounded ledges typical of black facies	101
Gray sandstone and barren quartzite:	
4. Orthoquartzite, feldspathic, very pale and grayish orange to very light and greenish gray; quartzitic, very fine grained; slabby, laminated and obscurely cross-laminated, locally thin bedded; orthoquartzite at top, 18 in. thick, is lenticular, thin-bedded, medium to coarse grained, and locally poorly sorted; locally spotted owing to metamorphism; interstital clay or chlorite(?); weathers very light gray, some grayish-red and moderate-reddish-orange stain; forms ledgy slope	24
Gray facies, incomplete:	
3. Siltstone, metamorphosed to hornfels, very light to pinkish gray; massive, laminated to very thin bedded; weathers grayish pink; forms slope with ledges	8
2. Covered	25
1. Diabase	Not measured
Total upper member (incomplete at bottom)	367

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The U.S. Geological Survey Library has catalogued this publication as follows:

Granger, Harry Clifford, 1925–

Stratigraphy of the Dripping Spring Quartzite, southeastern Arizona, by H. C. Granger and R. B. Raup. Washington, U.S. Govt. Print. Off., 1963.

vi, 119 p. illus., maps (part col.) diagrs., tables. 24 cm. (U.S. Geological Survey. Bulletin 1168)

Part of illustrative matter fold. in pocket.

Prepared on behalf of the U.S. Atomic Energy Commission.

Bibliography: p. 116–119.

(Continued on next card)

Granger, Harry Clifford, 1925– Stratigraphy of the Dripping Spring Quartzite, southeastern Arizona. 1963. (Card 2)

1. Geology, Stratigraphic — Precambrian. 2. Geology — Arizona. 3. Quartzite. I. Raup, Robert Bruce, 1929– joint author. II. Title. III. Title: Dripping Spring Quartzite, southeastern Arizona. (Series)

U.S. GOVERNMENT PRINTING OFFICE : 1964 O—695-977