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GEOLOGY OF THE SOUTH PAVANT RANGE

MILLARD AND SEVIER COUNTIES, UTAH

A Thesis

Submitted to the

Faculty of the Department of Geology

Brigham Young University

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

by

Gary Wayne Crosby

August 1959

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ABSTRACT

The south end of the Pavant Mountains is situated 160 miles south of Salt Lake City between US Highways 91 and 89, and immediately south of Kanosh in the southeast corner of Millard County, Utah. The Pavant Range is situated astride the boundary between the Basin and Range and Colorado Plateau Provinces.

A complete section of sedimentary rocks, representing every period since Precambrian time, is exposed in the south end of the Pavant Range. In general, Paleozoic strata aggregating 10,122 feet are similar to units described in the Great Basin, though somewhat thinner, and reflect a shelf to proximal miogeosynclinal depositional environment. Mesozoic-Cenozoic sediments are continuous with stratigraphic units of the Colorado Plateau, but lithologies reveal diverse depositional environments.

Extrusive volcanics, which spread north from the Marysvale area during Late Tertiary time, cover much of the south end of the Pavant Mountains. Various types include rhyolite, quartz latite, agglomerate, tuff, and basalts. Volcanics of the Mount Belknap Series, mostly rhyolite, cover the south end of the area investigated.

The Pavant overthrust fault places Cambrian quartzites and carbonates on top of Jurassic sandstone. Minimum displacement along this fault is 15 miles and the southern edge of the upper plate probably lies within the mapped area. Normal faulting is a common structural feature in the range, especially along the west face.

Sulfur, fluorspar, and minor base metals, genetically associated with intrusives in the Tushar Range immediately to the south, occur as vein minerals of commercial grade in the area.

INTRODUCTION

LOCATION AND ACCESSIBILITY

The Pavant Range is situated in south-central Utah about 150 miles south of Salt Lake City. Only the southernmost part of the range, in the southeast corner of Millard County, is considered in this report. Corn Creek lies approximately on the northern boundary of the mapped area, and US Highway 91 and Utah Highway 13 form the western and southern boundaries respectively. The settlement of Kanosh (pop. 476) is situated approximately on the northern boundary of the area.

Longitudes 112°17' and 112°36' west and latitudes 38°34' and 38°47' north encompass the area.

US Highway 91, paralleling the west face of the Pavant Range, is a major route of travel, and thus is the main access road. Utah Highway 13 connects US Highways 91 and 89 through Clear Creek Canyon giving easy access to the south end of the range. The US Forest Service maintains a gravel road which connects Kanosh with Clear Creek Canyon rendering accessible the interior of the range. In addition, the Forest Service has constructed several jeep trails, some of which the Cattlemen's Association maintains, allowing penetration to the higher elevations.

PHYSICAL FEATURES AND WATER RESOURCES

The Pavant Mountains trend essentially north-south; however at the south end, in the area of the present investigation, the range makes an arcuate swing toward the southwest. These southwest trending strata hold up a series of high ridges that are deeply dissected by numerous canyons.

Extrusive volcanics, spreading north from the Marysvale volcanic center, have merged with the sedimentary strata at the south end of the range. The erosional edge of the volcanics forms a strike valley dividing the range into two northeast-southwest trending ridges with the volcanic ridge standing in higher relief.

Relief in the mapped area is 4175 feet with a maximum elevation of 9310 feet above mean sea level and a minimum elevation of about 5135 feet. Rhyolite of the Mount Belknap Series is easily dissected and forms steep-walled canyons, and the cliff forming habit of the resistant Navajo Sandstone adds to the ruggedness of the area. Faulting of the competent Paleozoic carbonates produces rugged topography on the west slope of the range.

The Second Creek-Corn Creek system drains most of the area and forms a perennial stream which is an important source of irrigation water for the people of Kanosh. Several sag ponds exist near Baker Canyon into which large intermittant streams empty; recent drilling has proven large reserves of

INDEX MAP OF UTAH

showing mapping in adjacent areas

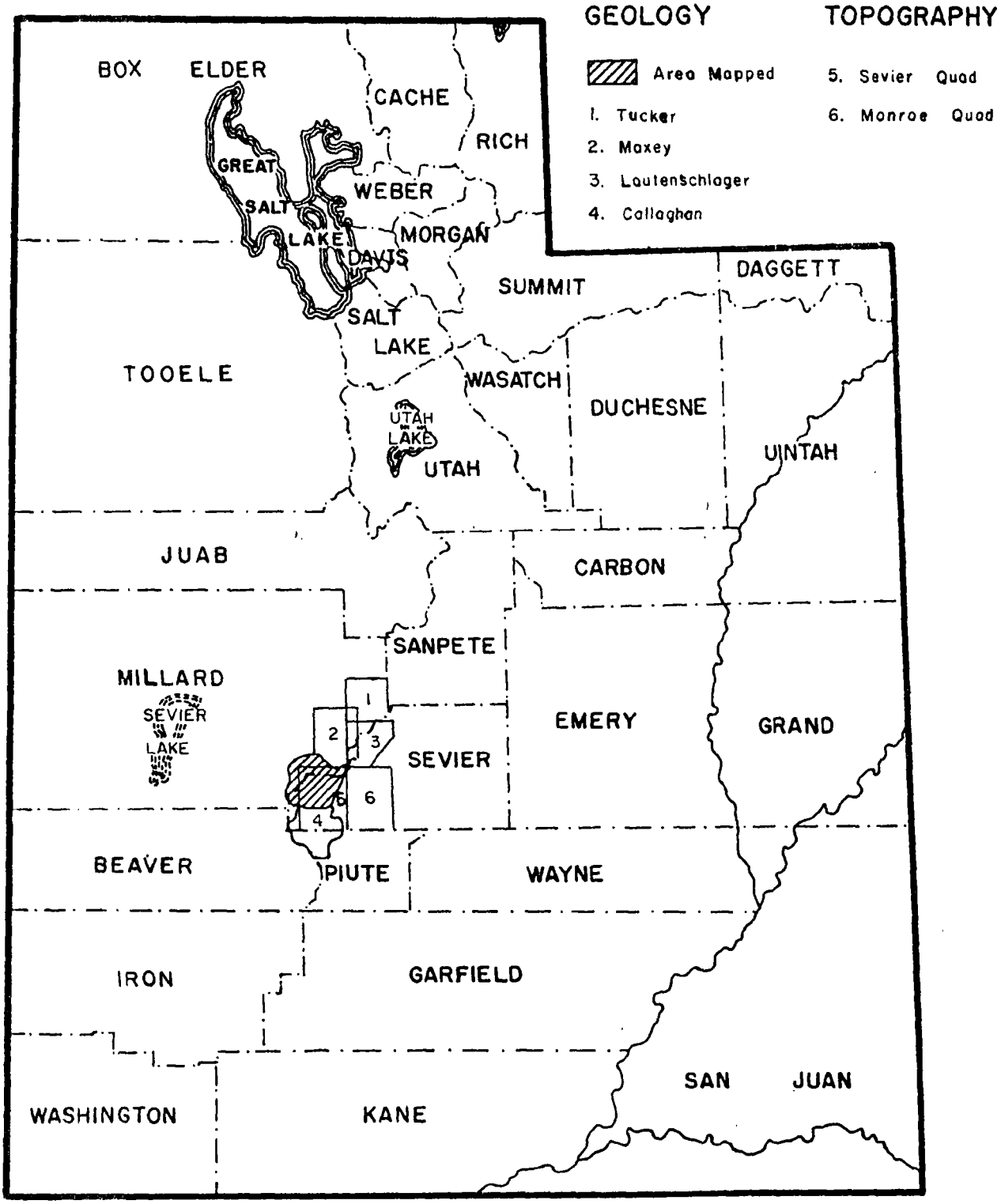


FIGURE 1

ground water in these localities. Except for Corn Creek all streams emptying into Pavant Valley from the southern end of the mountains are intermittant even though springs exist near the heads of several of the larger canyons. Water from these springs sinks quickly into the stream bed gravel, emerging briefly at outcrops of bedrock, and ultimately entering Pavant Valley recharging the ground water resources.

The water resources of the valley have not yet been fully exploited. The water table in a well seven miles due west of Kanosh and 1½ miles north of the mountain front stands at 68 feet (Moore, personal communication). This same well, bottomed in a vesicular basalt, delivers 5.33 second-feet of water on vacuum. While this figure is somewhat above average, it is indicative of the potential of the valley.

A virtual underground stream flows to the surface at Big Spring in Corn Creek Canyon. This spring is located along the trace of the Pavant overthrust fault and produces 4.75 second-feet of water (measured April 10, 1959). Several smaller springs are located along the same fault trace.

Features of glaciation are not found in the southern part of the Pavant Mountains though they are prevalent further north in the range (Lautenschlager, 1952, p. 146) and in the Tushar Mountains just south of Clear Creek (Callaghan, 1939, p. 441).

The Pavant Range is situated astride the boundary between the Great Basin and the Colorado Plateau and structural and topographic features of both provinces are recognizable. Fenneman (1931, p. 297) placed the Pavant Range entirely within the boundaries of the High Plateaus sub-division of the Colorado Plateau, though he observed that the range did not fit satisfactorily into this classification. The range lies completely within the internal drainage basin of the Basin and Range Province; sufficient reason perhaps for including the mountains in that Province. Dutton earlier suggested (1880, p. 3) that the boundary might best be drawn at the Paleozoic-Mesozoic contact through central Utah. Such a division would place parts of the range in each Province.

CLIMATE AND VEGETATION

The weather station at Fillmore, Utah reported an annual average temperature of 51.4 degrees fahrenheit for the period of 1948 to 1959 with January and July being the coldest and hottest months respectively. During the same period of time the average annual precipitation was 15.5 inches with December being the wettest month and June being the driest.

The Great Basin is effectively in the rain shadow of the High Sierras of eastern California. The effects of having the atmospheric water extracted from the westerly winds by this mountainous barrier are severely felt throughout the Great Basin, even at the eastern edge.

The above, and other meteorological conditions, have produced an arid to semi-arid climate on the west slope of the Pavant Mountains. When rain storms occur they usually come as cloudbursts of short duration. A heavy snow pack collects in the higher elevations during the winter months and the communities at the foot of the mountains are able to use much of this water by methods of irrigation and indirectly, by exploiting the ground water resources.

The usual desert flora of sage brush, and cacti flourish on the valley floors around the Pavant. The less rugged slopes are sparse to thickly covered with scrub oak, interrupted occasionally by stands of red cedar and cliff rose. Higher on the slopes, especially on the north sides, pinon pines are found growing. Along the high volcanic ridge in the southeast part of the area dense stands of aspen occur. The deep canyons, containing perennial streams, support a lush growth of cottonwoods, box elders, maples, and bunch grass, and where cattle frequent the streams cuckleburrs are found. The US Department of Agriculture has planted several grass plots of smooth brome (Bromus inermis) within the area.

FIELD WORK

Field work was initiated in September 1958 and completed in June of 1959. Geologic data was plotted on aerial photographs having a scale of approximately 1:21,000 as observations were made in the field. With the aid of the stereoscope formational contacts were drawn on the photographs after being located along traverses made during the course of field work. Plotting of the contact between volcanics and sediments and the unconformable contact between Price River conglomerates and older beds did not lend itself readily to the above method; consequently the areal extent of the volcanics and the conglomerates was mapped by walking out the contacts. A small part of the volcanics was mapped using the Sevier Quadrangle Topographic map as a base.

The data thus plotted on the aerial photographs and topographic map was transferred, in whole, to controlled photomosaics from which the final draft of the map accompanying this report was made.

Characteristic rock and fossil samples were collected for laboratory study, and stratigraphic sections were measured with steel tape.

PREVIOUS WORK

Before 1946 no detailed work had been done in the Pavant Mountains. Wheeler (1875, p. 59) was perhaps the first to refer to the geology of the range in a published report. In his report on the Survey West of the 100th Meridian he included a cross section to support his hypothesis of a Late Jurassic uplift of the range. His cross section showed neither Basin and Range faulting nor the major overthrust, though the strati-

graphic relations were essentially correct. Dutton (1880, p. 3), unsatisfied with the existing classification of the Pavant Range as belonging to the Colorado Plateau, concluded that the line separating the provinces should be drawn at the Paleozoic-Mesozoic contact in the Pavant Range. Dutton included a cross section by E. E. Howell which showed the structural relations, in addition to the stratigraphic relations, to be generally correct. Gilbert (1890, p. 335), in connection with his Lake Bonneville studies, made brief reference to the basalt flow in the northwest corner of the mapped area.

Recently much detailed geologic work has been done north of Corn Creek. Maxey (1946, pp. 324-356) mapped the west slope of the mountains between Corn Creek and Pioneer Creek in conjunction with ground water studies in Pavant Valley. His work was a "detailed reconnaissance" in that a thick section of Cambrian carbonates was not differentiated and the thick Cretaceous-Tertiary sedimentary sequence, forming the east slope of the range, was lumped as the "Wasatch" Formation.

In 1952 Lautenschlager completed a detailed study of the east slope of the Pavant Mountains from Richfield to Round Valley. And in 1954 Tucker worked out the geology of the Scipio Quadrangle, thus completing geologic mapping in the north end of the range.

Callaghan (1939, pp. 438-452) and Kerr (1957) have published the results of their work on the volcanic sequence in the Tushar Mountains just south of the Pavant Range.

In a small area just north of Corn Creek the present study overlaps with the work of Maxey. Though there is overlapping, and considerable geologic work has been done in adjacent areas, a complete Paleozoic section with large areal extent, confined within the limits of the present study, has required that the investigation be conducted along new lines.

PURPOSE AND SCOPE

Geologists whose interest has been in either the Great Basin or the Plateau Country have long been in need of stratigraphic descriptions from an area along their mutual boundaries. Paleozoic sediments are only scantily known from the Colorado Plateau, being covered by the later Mesozoic sequence, and the Mesozoic sediments are virtually unknown in the Great Basin, having long been eroded away. Working out the stratigraphic and structural relations in the transition zone will aid substantially in giving continuity to the geology of these two important geologic provinces.

The investigation of the south end of the Pavant Range was undertaken in the interest of the above cause. While geologic maps of areas astride this boundary exist, nowhere outside the present area is a complete Paleozoic-Mesozoic section exposed. And the section in the Pavant Mountains was found to be more complete than at first suspected.

Due to the fortuitous exposure of some 17,264 plus feet of beds originally deposited in this area primary emphasis has been placed on stratigraphy and structure. The igneous and economic aspects of the region are touched on briefly, but occupy a subordinate place in this report.

STRATIGRAPHY

GENERAL FEATURES

The rocks in the south end of the Pavant Range may be divided into four major groups. Along the northwestern front of the range, between Corn Creek and Baker Canyon, thick sections of marine Paleozoic carbonates and sands are exposed in the overturned limb of an asymmetrical syncline; the center of the range is composed of Mesozoic redbeds and eolian deposits; the eastern slope of the mountains is made up of an eastward dipping sequence of post-Laramide fluviatile and lacustrine deposits; and Tertiary rhyolite now covers the sedimentary rocks at the south end of the range.

The mapped area covers approximately 200 square miles. Stratified sedimentary rocks are exposed in about two thirds of this area with an aggregate thickness of nearly 15,000 feet. All systems since Precambrian time are represented, including some questionable Silurian dolomites, to give a complete section with a relatively continuous historical record.

The use of the phrase "complete section" in this paper is not to be construed as meaning the geologic record is without depositional breaks, for such is not the case. But all sediments originally deposited in the area, which survived subsequent periods of erosion, are now exposed, with the exception of the Upper Cambrian Opex Dolomite which is exposed just outside the northern boundary of the mapped area. Drilling records or the piecing together of stratigraphic sections from surrounding localities would not make the section more complete, except to include the Opex Dolomite.

CAMBRIAN SYSTEM

Tintic Quartzite

Definition: Loughlin (1919, p. 23) defined the Tintic Quartzite to include over 6000 feet of grayish-white to very pale pink quartzite composed of almost pure quartz with several thin pebble conglomerate beds. The Tintic is conformably overlain by the Ophir Formation and the base is not exposed in the type locality on Quartzite Ridge near Eureka, Utah. Cross-bedding is occasionally conspicuous, but, more often, bedding features of any kind are not observed. The breaking up of the formation into rubble of blocks up to 3 feet in thickness is largely controlled by a well defined joint system.

Distribution and lithology: In the south end of the Pavant Range the Tintic Quartzite crops out along the western slope of the mountains and forms the high ridge in the center of the range just north of Corn Creek. The westernmost exposures parallel US Highway 91 from 5 to 7 miles west of Kanosh where the formation rests in thrust relationship on younger Paleozoics. Imbrication repeats the section at least 3 times which is readily shown by the occurrence of the same limestone bed of

TABLE I

STRATIGRAPHIC SUMMARY OF THE SOUTH PAVANT MOUNTAINS

AGE	FORMATION	THICKNESS	CHARACTERISTIC LITHOLOGY
Quaternary	Alluvium		Silt, sand, and gravel.
Quaternary	Pavant Basalt	12 feet	Basalt, reddish-black, vesicular.
Quaternary-Tertiary	Sevier River Formation	92 feet	Boulder conglomerate, sand, and clay.
Tertiary	Mount Belknap Series	2560 feet	Rhyolite, blue-gray; Tuff; Agglomerate; Quartz Latite
Tertiary-Cretaceous	North Horn Formation	140 feet	Sandstone and siltstone, red and brown, channeled.
Cretaceous	Price River Formation	850 feet	Pebble to boulder conglomerate, deep reddish-gray.
Jurassic	Navajo Sandstone	1742 feet	Sandstone, brick red, fine grained, cross-bedded.
Triassic	Chinle Formation	274 feet	Sandstone and mudstone, variegated, cross-bedded.
Triassic	Shinarump Conglomerate	428 feet	Gritstone, sandstone, and pebble conglomerate, tan.
Triassic	Moenkopi Formation	1054 feet	Siltstone, deep red, ripple marks; gray limestone.
Permian	Kaibab Limestone	1193 feet	Limestone, light gray, coarse crystalline; sand.
Permian	Coconino Sandstone	288 feet	Sandstone, yellow-tan, quartzitic, cross-bedded.
Permian	Pakoon Limestone	174 feet	Limestone, dolomitic, tan-gray, calcite blebs.
Pennsylvanian	Oquirrh Formation	949 feet	Limestone, dark gray, platy, quartzite and dolo.
Mississippian	Redwall Limestone	273 feet	Limestone, reddish-gray, coarse crystalline.
Devonian	Cove Fort Quartzite	83 feet	Quartzite, cream-white, pure, well sorted quartz.
Devonian	Guilmette Formation	570 feet	Dolomite, dark gray; limestone and brown quartzite.
Devonian	Simonson Dolomite	239 feet	Dolomite, reddish-brown, white calcite stringers.
Devonian	Sevy Dolomite	673 feet	Dolomite, light gray, dense, aphanic.
Silurian (?)-Ordovician	Fish Haven-Laketown Dolomite	1000 feet	Dolomite, dark gray, red chert, algal structures.
Ordovician	Swan Peak-Eureka Quartzite	178 feet	Quartzite, white, vitreous purple streaked.
Ordovician	Pogonip Limestone	1110 feet	Limestone, medium gray, silty; shale, olive.
Cambrian	Carbonates	1681 feet	Limestone, dark gray; Dolomite, light gray.
Cambrian	Ophir Formation	418 feet	Limestone, dark gray; shale, steel gray, papery.
Cambrian	Tintic Quartzite	1293+feet	Quartzite, white, iron stained, pink streaked.

the Ophir Formation appearing thrice across the low exposures of quartzite. North of Corn Creek the Tintic Quartzite appears briefly in the mapped area, but is cut out by thrusting and is not included in the allochthon south of Monk Spring; however the formation forms the high ridge of the range and extends to within 5 miles of Escalante Pass at the north end of the Pavant Mountains (Tucker, 1954, p. 14). Several small klippen patches of Tintic occur on the higher ridges between the two major exposures.

The Tintic Quartzite in the Pavant Range is very similar to that in the type locality in that it is predominantly grayish-white grading to pale pink in occasional thin bands. Near the base of the exposed section a massive 22 foot bed of deep purple quartzite occurs. Several pebble conglomerate beds as much as two feet thick may be observed throughout the section, especially near the lowermost exposures. Although the rock is highly indurated and fractures across the grain, individual grains can usually be distinguished. The formation is composed of almost pure vitreous quartz with occasional dark reddish-purple grains of chert. Yellow, brown, and red iron stains are common on weathered surfaces. The formation is highly fractured due to disturbance in the thrusting movement and the bedding is obscured.

Perhaps a notable difference between the Pavant section and the type locality is the occurrence of thin alternating beds of green, phyllitic shale with irregular bedding in the uppermost 80 feet of the formation in the Pavant Range.

The base of the formation is not exposed; the sole of the thrust plate could conceivably correspond to the stratigraphic base; however a thinning from 2620 feet thick on Fillmore Peak (Lautenschlager, 1952, p. 18) to an estimated thickness of 1000 feet at Monk Spring would seem to rule out this possibility. The stratigraphic relationship with the superjacent Ophir Formation is conformable, and with the contact placed at the base of a 35 foot thick deep reddish-brown, argillaceous limestone bed, the lithologic change is abrupt.

<u>Age, correlation, and thickness</u>: Fossils were not found in the Tintic Quartzite in the Pavant Range; neither have they been reported from other localities. The similarity of lithology, however, leaves no doubt as to the correct identification of the formation.

The same lithologic sequence of basal quartzites, to shales, to carbonates suggest that the Tintic in this area may be correlated, at least in part, with the Prospect Mountain Quartzite of the Great Basin, the Brigham Quartzite of northern Utah, and the Tintic Quartzite at other localities in central Utah. Walcott (1908, p. 171) found Lower Cambrian trilobites in the overlying shale in the House Range, but in the northern Wasatch Mountains he found a lower Middle Cambrian fauna, though the containing shale bed occupied the same lithologic position in the sequence. This, then, indicates temporal transgression from

west to east during Lower and Middle Cambrian time, a relationship which is in agreement with later workers in the Middle Rocky Mountains.

The trilobite fauna found in the overlying shale in the course of the present investigation establishes the minimal age for the Tintic Quartzite in the Pavant Range as lower Middle Cambrian. Thus the age of the formation, at least the part exposed, is, most likely, Lower Cambrian.

The green phyllitic shale beds in the upper 80 feet of the formation are lithologically similar to the Pioche Shale of the Great Basin and equivalence seems possible, although Olenellus was not found. If these beds may be correlated with the Pioche Shale, then the Tintic Quartzite in this area can be no younger than Lower Cambrian.

The exposures of Tintic Quartzite on the north side of White Sage Flat are 1293 feet thick.

Ophir Formation

Definition: Butler (1920, p. 374) described the Ophir Formation from exposures in Ophir Canyon in the Oquirrh Range approximately 20 miles southwest of Salt Lake City. The formation is predominantly papery to thin bedded fissile shale with light and dark beds of limestone. It was defined to include the shale sequence between the basal quartzites and the massive Cambrian carbonates above.

Distribution and lithology: In the Pavant Mountains the Ophir Formation is restricted to the allochthon; hence its distribution is essentially the same as that of the Tintic Quartzite. It does not, however, occur as isolated patches resting on the Navajo Sandstone as does the Tintic. The Ophir Formation is well exposed on the south side of US Highway 91, 4 to 6 miles west of Kanosh. There the formation caps the top of the quartzite hills. The Ophir is cut out by thrusting and is not found south of Monk Spring.

The formation is predominantly argillaceous limestone with shale interbeds commonly occuring throughout. Two thick, deep reddish-brown beds are dolomitic. Dark gray, coarse crystalline limestones in the upper half contain a high percentage of trilobite hash. A meringue surface is a common weathering feature on the limestones. The shales are usually covered, but where exposed, they appear steel gray and have a papery splitting habit. A 28 foot thick shale bed about midway in the formation contains abundant trilobite cephalons.

Age, correlation, and thickness: It was long thought that the Pioche Shale and the Ophir Shale were lithologic equivalents, although the Ophir, in the eastern part of the Great Basin, was considered to be slightly younger. Recent stratigraphic and paleontological work in the eastern Great Basin, however, has shown that the Ophir is stratigraphically above the Pioche

(Rigby, personal communication). The relationships discussed above would suggest that the same stratigraphic sequence occurs in the Pavant Range.

Trilobites collected from the Ophir Formation three quarters of a mile south of the gravel pit on Highway 91, 6 miles west of Kanosh, evidently date the formation early Middle Cambrian. The following trilobites were tentatively identified by Dr. J. Keith Rigby, with later measurements made by the writer substantiating the identification:

Pachyaspis typicalis
Alokistocare sp.
Poulsenia occidens
Prozacanthoides (?) sp.

These forms have elements of both Albertella and Ptarmigania faunas (Resser, 1939, p. 19) which are both considered to be early Middle Cambrian. Additional species occur in the fauna in the Pavant Range, but, due to the hashy nature of the fossils, positive identification was not possible.

The Ophir Formation is 418 feet thick on the north side of White Sage Flat.

Teutonic Limestone

Definition: The type locality for the Teutonic Limestone is on Teutonic Ridge in the Tintic district, Utah (Loughlin, 1919, p. 27). There the formation is a continuation of the limestones in the Ophir Shale with the contact being drawn at the top of the last shale bed. Argillaceous bands give the dark blue-gray limestone a mottled appearance on the weathered surface. An identifying feature in the type locality is the occurrence of numerous white calcite veinlets.

Distribution and lithology: One small patch of the Teutonic Limestone rests on top of the Ophir Formation near US Highway 91 west of Kanosh. North of Corn Creek the Teutonic outcrops above a strike valley formed on the Ophir Formation and trends north-south on the west slope of the range near the top. The formation occurs in the thrust plate; thus it is exposed only locally in the northeast part of the mapped area, as the allochthon is covered by the Price River and North Horn Formations just south of Corn Creek. The Teutonic Limestone forms the sole of the thrust plate for a short distance south of Monk Spring.

Lithologically the beds are similar to those at the type locality. The dark blue-gray, fine crystalline limestone contains much clastic material; light brown argillaceous bands produce a clouding effect on the dark gray weathered surface. Numerous white calcite veins occur which commonly exhibit a reddish layer on the outside of the veinlet. The formation typically forms steep slopes with several massive step ledges. The Teutonic rests conformably between the Ophir Formation below and the Dagmar Limestone above.

Age, correlation, and thickness: No fossils were found in the Teutonic Limestone at the type locality during the original investigation, nor have they been reported from the Pavant Range. None were found in the course of the present investigation; however the age of the formation may be determined by its position between beds of known Middle Cambrian age. The reasons for dating the Ophir Formation early Middle Cambrian have already been outlined, and evidence for assigning a late Middle Cambrian date to the Herkimer-Bluebird-Cole Canyon beds will be presented; thus the Teutonic is bracketed in Middle Cambrian.

Geologists working in Utah have had a tendency to extend stratigraphic nomenclature from locality to locality in a north-south direction rather than east-west. Good reasons exist for this practice as lithologic changes are more apparent in traversing from east to west. Zones of facies change parallel the Wasatch Line, a calculated line of demarcation between paleobasin and shelf, which trends essentially north-south in the state. Partly because of these conditions a different set of formational names for the Cambrian system has resulted for the Great Basin proper and the eastern edge of the Great Basin. Correlation is understandably difficult as different depositional environments have resulted in different lithic types. And characteristic animals often preferred one environment exclusively.

The thickness of the Teutonic Limestone is 424 feet at Monk Spring. This figure compares with 566 feet at the type locality.

Dagmar Limestone

Definition: Loughlin (1919, p. 27) named the Dagmar Limestone from the Dagmar mine in the Tintic district. The beds there are medium to dark gray, weathering yellowish to grayish-white and are very dolomitic.

Distribution and lithology: The outcrop pattern of the Dagmar Limestone is similar to that of the Teutonic Limestone, and similarly occurs only in the northwest part of the mapped area.

The light weathering surface and the cliff-forming habit of the formation makes it a distinctive sequence marker in the Pavant Range. The rock is crystalline and light gray on fresh surface in contrast to the darker grays in the Tintic district; however the beds are very dolomitic at both localities. The formation is thinly bedded, but partings along the bedding planes are poorly developed allowing the formation to stand in cliffs. The Dagmar is perhaps the most homogenous formation in the Pavant Range.

The Dagmar Limestone lies conformably between the Teutonic Limestone below and the Herkimer Limestone above. The beds above and below are dark bluish-gray and in sharp contrast to the lighter colored beds of the Dagmar.

Age, correlation, and thickness: The same evidence used in establishing the Middle Cambrian date for the Teutonic Limestone

is applicable to the Dagmar Limestone. The thickness of the formation above Monk Spring is 104 feet as compared with 100 feet at the type locality. The change in thickness is insignificant and lithologic changes are unimportant.

Herkimer-Bluebird-Cole Canyon

Lithology of the Herkimer-Bluebird-Cole Canyon sequence of dolomites and limestones in the Tintic district is distinctive for each formation; however in the Pavant Range the formations have been more or less arbitrarily chosen in the central part of the range (Lautenschlager, 1952, pp. 24-28), but because of the limited area of exposure it was found impracticable to differentiate between the formations in the area considered in this investigation.

Definition: Loughlin (1919, p. 28) named the Herkimer Limestone from Herkimer shaft near Quartzite Ridge, and the Bluebird and Cole Canyon Dolomites from topographic features in the Tintic district. There the Herkimer is a series of limestones and dolomites typically mottled and shaly. Much carbonaceous material gives the formation its dark bluish-black color. The Bluebird is a dark bluish-gray, fine-grained dolomite "spangled with short white rods" of calcite. The Cole Canyon is an alternating sequence of light and dark weathering beds of limestone and dolomite. The darker beds are somewhat argillaceous and carbonaceous. In the Tintic district the top of this sequence coincides with the boundary between Middle Cambrian and Upper Cambrian.

Distribution and lithology: The outcrop pattern of the Herkimer-Bluebird-Cole Canyon sequence is similar to that described for other Middle Cambrian units. This sequence forms the southernmost exposures of the upper plate of the Pavant overthrust.

The lower part of the sequence is a medium gray dolomitic limestone with white secondary calcite veinlets. These beds weather a dark gray with a slight reddish tint, and rarely small reddish specks may be observed on the fresh surface. Above this lower unit some massive ledges of alternating medium and dark gray dolomites occur. Calcite "rods" are common in the darker beds, most of which are only slightly dolomitic. The lighter colored beds are coarse crystalline homogeneous dolomite. The upper 400 feet of this sequence becomes somewhat argillaceous and less dolomitic. Several thin tan and red shale beds occur scattered throughout this top unit. This sequence conformably overlies the Dagmar Limestone and the top is not exposed, being capped in angular discordance by the Price River conglomerates.

Age, correlation, and thickness: A 3 foot thick coquina bed, composed almost entirely of *Eoorthis* sp., occurs near the top of the sequence in Corn Creek Canyon about 500 yards upstream from Big Spring. This form, however ranges from Middle Cambrian through Lower Ordovician and is of little value here, though it should be noted that this form occurs abundantly in the Secret Canyon Shale in the Eureka district, Nevada, and in the Wheeler Shale and the Marjum Limestone in the House Range, Utah, and an

upper Middle Cambrian age for these formations has been well documented.

Loughlin (1919, p. 29) reported the occurrence of Obolus mcconnelli in the shales at the top of the Cole Canyon Dolomite in the Tintic district, and Lautenschlager (1952, p. 28) reported the occurrence of Eldoradia prospectensis from the same horizon in the central Pavant Range. The occurrence of these two fossils suggest correlation between the Cole Canyon and the Marjum Limestone further west in the Great Basin. Walcott (1912, pp. 156, 197), even as far back as 1912, made this conclusion.

Since the Herkimer-Bluebird-Cole Canyon sequence was not differentiated in the present paper, the exact stratigraphic position of Eoorthis sp. is not certainly known; however lithologic similarities strongly suggest that the fossils are contained in the Cole Canyon Dolomite. By comparing thicknesses with those reported by Lautenschlager several miles north of the present area the fossiliferous horizon should be between 200 and 300 feet below the Cole Canyon-Opex contact. Thus an upper Middle Cambrian age for the top of the Herkimer-Bluebird-Cole Canyon sequence seems probable from the evidence available.

The thickness of the unit measures 1153 feet from the top of the Dagmar Limestone to the upper contact with the Price River Formation above Monk Spring.

ORDOVICIAN SYSTEM

Pogonip Limestone

Definition: The name Pogonip Limestone was first employed by King (1878, p. 188) and included all beds between the Prospect Mountain and Eureka Quartzites on Pogonip Ridge at White Pine, Nevada. Later the name was applied only to the Ordovician portion of the carbonate sequence (See Sharp, 1942, p. 657 for a history of the term). More recently, Hintze (1951) defined six new formations within the Pogonip Group, viz., the House Limestone, Fillmore Limestone, Wahwah Limestone, Juab Limestone, Kanosh Shale, and Lehman Formation. The characteristic lithology of the Pogonip Group is clastic limestone, light gray, fine-grained with intraformational conglomerate in the lower half and some sands and shales in the upper half.

Distribution and lithology: The best exposures of the Pogonip Limestone are on the east face of Baker Canyon and again slightly higher on the same ridge. Two small patches occur in imbricate thrusts on the east side of White Sage Flat. Outcrops are, at best, only poorly exposed, being covered by soil and the high level gravels of the Sevier River Formation. Because of their being poorly exposed and the possibility of structural complication the attempt to differentiate the units was abandoned.

At the base of the exposed section there is a thick sequence of medium gray, thin bedded limestones. These beds are very silty, and argillaceous material weathers a light brown, dulling

the surface. Occasional beds of twiggy bodies, intraformational conglomerates become more common above this unit. Several thick beds of crystalline, light to medium gray limestone occur about midway in the group. The upper half becomes more shaly; 6 inch interbeds of brown weathering limestone and shale are well exposed in a road cut on the east side of US Highway 91 in Baker Canyon. Near the top the fossiliferous shales become a deeper brown and the limestone becomes dark gray on fresh surface.

The base of the Pogonip is not exposed in the mapped area, and the Swan Peak-Eureka Quartzite apparently overlies the Pogonip in a conformable relationship.

Age, correlation, and thickness: Hintze (1952, p. 5) recognized 15 faunal zones in the Pogonip, most of which are recognized throughout the eastern part of the Great Basin. His work has established reliable dating for the formations of the Pogonip Group. His zones "B" through "K", corresponding to the House, Fillmore, and Wahwah formations, represent the Canadian of the Great Basin; and zones "L" through "N", corresponding to the Juab, Kanosh, and Lehman formations, are considered to be Chazyan in age.

Hintze visited the section in Baker Canyon in the summer of 1948 in connection with his work on the Lower Ordovician strata of western Utah (1951, p. 81) and he recognized almost the entire section, but reported the thicknesses as tentative owing to the beds being "masked by soil ----- overturned, somewhat distorted, and incompletely exposed".

All of the fossiliferous horizons reported by Hintze were located during the present investigation and most of the individual species were recognized. Although the Pavant section is not as fossiliferous as further to the west in the Ibex area, definite correlation was effected. Fossils recognized by Hintze for the south Pavant section are:

Orthis michaelis
Orthis sp.
Pliomerops sp.
Hesperonomiella minor
Lachnostoma latucelsum
Gastropods
Bryozoan fragments
Cystid fragments

Hintze demonstrated the areal extension of the Pogonip Group throughout western Utah and most of eastern Nevada. Comparison of the Pogonip faunas with those of the Garden City Formation in northeastern Utah (Ross, 1949) shows that many elements are identical.

The Pogonip is 1110 feet thick in Baker Canyon.

Swan Peak-Eureka Quartzite

Definition: The Swan Peak Quartzite was defined from exposures on Swan Peak in northern Utah (Richardson, 1913, p. 409), and included all beds between the previously defined Garden City Limestone below and the Fish Haven Dolomite above. The formation consist of two main lithic types: a fossiliferous shaly unit in the lower half and an upper vitreous quartzite member. The Eureka Quartzite was named by Hague (1883) in the Eureka district, Nevada.

Distribution and lithology: The exposures of the Swan Peak-Eureka Quartzite in the present area are in the same general localities as that of the Pogonip Limestone. Webb (1956, p. 61) suggested that outcrops of similar quartzites 1 mile south of the Baker Canyon exposures near Dog Valley, and 5 miles to the north in White Sage Flat were also outcrops of Swan Peak-Eureka. Areal Mapping, however, has shown that the quartzites near Dog Valley belong to a new formation of Upper Devonian age, and those at White Sage Flat belong to the Tintic of Cambrian age.

The top of the formation is composed of white vitreous quartzite with several vivid red and purple streaks inherent in the rock. Surficial reddish-brown streaks stain the outcrop. Cross-bedding is faintly obvious where the red and purple streaks occur. A middle unit consist of several interstratified beds of sandy dolomite. The base is mostly covered, but outcrops below the dolomite resemble the upper vitreous member, and float indicates that the base is made up of brown, less indurated proto-quartzites.

The lower contact is gradational and apparently conformable with the Pogonip while the upper contact with the Fish Haven is sharp and possibly disconformable.

Age, correlation, and thickness: To the west, in the Ibex area, an intervening 85 foot thick dolomite unit, the Crystal Peak Formation, separates the Swan Peak and Eureka quartzites. This dolomite formation contains several thin beds of limestone, bearing the coral Eofletcheria in biostromal quantities, and the lower member of the Swan Peak Quartzite in northeastern Utah bears fossils similar to those found in the Kanosh shale, all of which dates the quartzite sequence Medial Ordovician, at least in those localities. The stratigraphic position in the Pavant Range suggest the same age.

Until recently it was thought that the Swan Peak and Eureka quartzites were equivalent. Webb (1956) has presented evidence to show that the Swan Peak is older than the Eureka which stratigraphically overlies it in western Utah. Webb considers the Swan Peak to be sand deposition in a regressive sea during Medial Ordovician time, and the Eureka possibly representing a transgressive tongue pointing eastward out of Nevada. The thickness of the Ordovician quartzite in Baker Canyon is 178 feet.

ORDOVICIAN AND SILURIAN (?) SYSTEMS

Fish Haven Dolomite

Definition: Richardson (1913) defined the Fish Haven Dolomite from exposures on Swan Peak Mountain near the Utah-Idaho border. A Richmondian fauna was collected from the fine-textured, dark gray to blue-black, locally cherty dolomite.

Distribution and lithology: In general, a resistant ledge of Fish Haven Dolomite forms the lowest outcrops of the overturned limb of Paleozoics on the northwest face of the Pavant Mountains. Outcrops are continuous from Dry Wash to Baker Canyon. Good exposures may be observed anywhere along this outcrop belt; however the only complete section is in Baker Canyon.

Except for 82 feet of beds at the top, the character of the rock is unusually constant. It is a dark gray, dense, fine-crystalline dolomite with its most distinctive feature being the presence of large algal structures, up to 4 feet in diameter. These structures are dolomitized in some beds and silicified in others; both types resist weathering and are etched into relief, creating the so-called "curly beds", producing a rough, knarly surface. The beds contain white and black, bedded chert throughout and locally make up 40 percent of the rock. The upper 82 feet grades from dark gray to light gray. The algal structures are conspicuously absent. These beds are dense and somewhat homogenous except for occasional small ribbons of chert.

In the type locality the lower contact is disconformable. A 2 foot bed of sandy dolomite at the base is indicative of a similar relationship in the Pavant Mountains. A probable depositional break occurs at the top of the formation, although field evidence is lacking.

Age, correlation, and thickness: While the beds herein described have been mapped as Fish Haven, the possibility of the upper part of the formation being equivalent to Silurian Laketown Dolomite must be admitted. The lower major member, composed of curly beds, is identical to the Fish Haven in the Confusion Range, even to the inclusion of dolomitized outlines of *Halysites* and *Streptelasma*. An obvious lithologic change occurs in the thin upper member, and the unit vaguely resembles the lithology of the Laketown; however identification on lithic character is somewhat tenuous since, within the unit, there is a gradual and complete gradation from typical Fish Haven lithology on the bottom to typical Sevy above. Rare occurrences of *Favosites* at the base of the Pavant section identifies the formation with the Fish Haven of the Great Basin which is Upper Ordovician in age.

The top of the formation was drawn at the last chert band. This breakdown gives a total thickness of exactly 1000 feet for the Fish Haven Dolomite.

DEVONIAN SYSTEM

Sevy Dolomite

Definition: The Sevy Dolomite was named by Nolan (1935, p. 18) from exposures in Sevy Canyon in the Deep Creek Range, Utah. Typical rock in the formation is a "mouse-gray" dolomite that weathers very light gray. It is an extremely dense, aphanic dolomite and has a conchoidal fracture.

Distribution and lithology: The distribution of the Sevy Dolomite is similar to the Fish Haven Dolomite, outcropping only in the overturned fold trending northeast-southwest.

The description of the formation from the type locality fits well a thick middle member in the Pavant Range. It is dense and aphanic with a subconchoidal fracture, and it has a dull, medium gray color. A fine-crystalline unit is present at the bottom and also at the top. The entire formation weathers chalky white which shows up conveniently on aerial photographs. Locally near the top, there are beds containing tiny nodules of light-colored chert. Digested in acid the rock yields 8.7 percent insoluble residue of bentonitic clay. The subjacent relationship with the Fish Haven has already been discussed and the upper contact is conformable.

Age, correlation, and thickness: As no fossils were found in the Sevy, and since no good diagnostic fossils have been reported from nearby localities, its age is not definitely known. The Sevy grades into the Simonson Dolomite which has been accurately placed in Middle Devonian in the Gold Hill district (Nolan, 1935, p. 20). Its minimum age then is Middle Devonian, and probably most of the formation was deposited in Mid-Devonian seas.

The thickness, measured on the southeast edge of White Sage Flat, is 673 feet.

Simonson Dolomite

Definition: Nolan (1935, p. 19) defined the Simonson Dolomite from exposures of brown, sugary-textured, laminated dolomites conformably overlying the Sevy Dolomite in Simonson Canyon in the Deep Creek Range, Utah. The dark gray dolomite grains are large enough to be seen with the unaided eye.

Distribution and lithology: The Simonson rest conformably on the Sevy Dolomite in the Pavant Mountains, and is of similar extent. Two small patches of Simonson occur in imbricate faults near Dry Wash.

The formation is easily identified by its deep brown weathering color and the presence of curled filaments of white secondary calcite contrasting sharply with the brown dolomite. Medium sized grains of dark gray dolomite give the outcrop a sugary texture on the weathered surface. Micro-laminations are observed in thin section, and near the top the laminations become large enough to be seen without magnification. A few light gray dolo-

mite beds occur near the top. The contacts are well defined and conformable both above and below.

Age, correlation, and thickness: The Simonson in the Gold Hill district contains a Middle Devonian fauna. The only fossil found in the Pavant exposures is the coral *Coenites cryptodens* which substantiates the age of the formation.

The formation was measured on the southeast edge of White Sage Flat. The thickness is 239 feet which compares with 1030 feet at the type locality. The thinning of the formation in its eastward extension from the Great Basin proper is typical of almost all of the Paleozoic units in their shelfward extensions. The presence of beds of sand in many of the Paleozoic formations in the Pavant Range, as well as the thinning of units from western Utah to central Utah, may be considered indicative of the Pavant's position at the eastern edge of the Paleozoic miogeosyncline.

Guilmette Formation

Definition: Guilmette Gulch, on the west side of the Deep Creek Mountains, is the type locality for the Guilmette Formation. Nolan (1935, p. 20) defined the unit to include all beds between the Simonson Dolomite and an unconformity at the base of the Carboniferous in the Gold Hill district. There the beds are chiefly dolomite with several massive light bluish-gray limestone beds, and some lenticular sandstones. The *Striatopora*-bearing dolomites are medium to dark gray and medium crystalline.

Distribution and lithology: The Guilmette is exposed only in the overturned fold. Its extent is similar to the other Devonian units, except, however, much of its westward extension, on the south side of White Sage Flat, is cut out by faulting. Some crushed and crumpled beds near Baker Canyon are probably Guilmette.

Field identification of the Guilmette Formation was facilitated by the presence of several lenticular sandstones, most of which are highly indurated quartzites or protoquartzites. The base is defined by a 15 foot quartzite bed. A thick, persistent quartzite bed at the top has been defined for the first time in this paper and given a new name, as will be discussed later.

Dark gray, medium crystalline dolomites predominate in the formation; these show some reddish brown specks and occasional white calcareous stringers. Thick bedded, dark blue-gray limestone interbeds are prevalent which weather a dark gray with clouds of tan argillaceous discoloration. The quartzites are usually brown, but white to cream vitreous quartzites occur near the top.

In the lower half of the formation some light colored laminated beds persist. Near the base dolomitic intraformational breccia, resembling the thick breccia beds of the Guilmette in the Confusion Range, commonly appears as float, although it was not observed in bedrock. The breccia is composed of pebble size dark gray to black, fine crystalline dolomite fragments set in

a white crystalline calcite matrix. This rock is probably the result of slumping on the ocean floor, although such an explanation seems too simple for such thick deposits as occur in the Confusion Range.

Age, correlation, and thickness: The fossil Coenites cryptodens, the same found in the top of the Simonson Dolomite, occurs near the base of the Guilmette. According to Gould (in preparation) this form is abundant in the Guilmette in the Confusion Range where it comprises part of a Middle Devonian fauna. The formation is moderately fossiliferous in the type locality, and is considered there to be Middle Devonian (Nolan, 1935, p. 21). The Guilmette in the Gold Hill district may be younger, in its upper portions, than the top of the formation in the Pavant Range. With the Simonson Dolomite, of Middle Devonian age, conformably underlying the Guilmette, the formation may be assigned to Middle Devonian. The formation is 570 feet thick at the southeast corner of White Sage Flat.

Cove Fort Quartzite (new name)

Definition: The name Cove Fort is proposed for a cream-colored, vitreous quartzite formation resting conformably above the Guilmette Formation in the south end of the Pavant Mountains. This unit is exposed in the overturned limb of an asymmetrical syncline resting in thrust relationship on Triassic beds. This unit is of uniform thickness and is persistent in the exposures of the overturned beds.

The section was measured and described in sec. 16, T. 24 S., R. 6 W. at the southeast corner of White Sage Flat. Good exposures, however, may be seen from US Highway 91 at the north edge of Dog Valley.

Distribution and lithology: The exposures of the Cove Fort Quartzite occur about midway up the ridge formed by the overturned Paleozoics and extends the length of this tectonic feature for approximately 12 miles. About 4 miles of exposures extends to the west of the mapped area; the formation was not walked out west of Baker Canyon, but its presence was noted.

Lithologically, the formation may be divided into three units: the lower unit, which is the thickest, is composed of white to cream, highly indurated, clean quartz sand, the middle unit is a light gray limestone intraformational breccia with considerable sand, and the upper unit is a reddish-gray, poorly sorted quartzite with calcareous cement acting as binder. There is an erosional surface at the top of the formation.

Age, correlation, and thickness: The Cove Fort Quartzite is contained between beds of Lower Mississippian and Middle to Upper Devonian age, but an unconformity exists at the base of the Mississippian strata. The Cove Fort may be either Middle Devonian or Upper Devonian, but it is probably Upper Devonian.

The Victoria Quartzite of the Tintic district (Loughlin, 1919, p. 38) occupies the same stratigraphic interval as does

the Cove Fort; however an erosion surface exists at the base of the Victoria, and for this reason Loughlin assigned the formation to Lower Mississippian. In addition to its being considered younger, the Victoria Quartzite is a dark sandy limestone with a few dark quartzitic beds, and is at great lithologic variance with the Cove Fort; although the two formations are of approximately equal thickness.

Rush (1951, p. 16) described a Devonian section in the Burbank Hills of western Utah in which he found thick unfossiliferous strata above a Stringocephalus zone of Middle Devonian age. These beds, however, are mainly composed of black, thin bedded, nodular limestone and bear no resemblance to the Cove Fort. The possibility exist that the Cove Fort is a nearshore facies to these basin carbonates, but without fossil evidence such a conclusion is somewhat presumptuous. Assuming equivalence of the two formations, the carbonates would indicate that the source of the Cove Fort sands is not from the west. If the clean, well sorted sands of the Cove Fort are a strand line deposit in a regressing sea, as it seems likely, the sea would have withdrawn from the shelf and the source would have been from the east, or constitute reworked bottom sediments over which the westward moving shoreline retreated.

The thickness of the Cove Fort is 83 feet at the southeast edge of White Sage Flat, and is 85 feet along the highway near Dog Valley.

MISSISSIPPIAN SYSTEM

Redwall Limestone

Definition: Gilbert, working under Wheeler (1875, p. 178), applied the name Redwall to massive limestone cliffs at the junction of Kanab Creek with the Colorado River in Grand Canyon. The limestone is a medium to dark gray crystalline rock with minor occurrences of chert. The cliffs weather gray with a rusty red hue; hence the name Redwall. Some sandstone interbeds appear near the top.

Distribution and lithology: The Redwall outcrops on the northwest face of the southern Pavant Mountains with the other Paleozoic formations and is of similar extent. Good exposures may be seen from US Highway 91 on the north side of Dog Valley.

The formation consists of thick to massive beds of coarse crystalline, oolitic limestone. The formation is abundantly fossiliferous with encrinite beds occurring near the base and also at the top. Silt is conspicuous midway in the formation which gives the dark bluish-gray exposures a faint laminated appearance. The fresh surface of the rock has a definite reddish cast, and the rock emits a fetid odor when struck with a hammer. The base of the Redwall is disconformable with the Cove Fort Quartzite and also disconformable with the Oquirrh Formation above.

Age, correlation, and thickness: The Redwall Limestone of the

Pavant Mountains yielded a prolific fauna which includes corals, brachiopods, fenestrellid bryozoans, endothyroid foraminifera, and the characteristic Redwall gastropod, Euomphalus. Many elements of this fauna require additional work before positive identification can be made, but on the basis of the following occurrences attesting an Osagean age, assignment of the formation to the Redwall of Lower Mississippian age seems justified:

Triplophyllites subcrassus
Triplophyllites paucicinctus
Canina sp.
Plectogyra sp.
Euomphalus sp.

A series of Lower Mississippian limestones extending from Alberta to southern Arizona is perhaps the most persistent lithologic unit in the Inter-Cordilleran region. These beds are characterized by the inclusion of abundant fossils by which paleontologists have demonstrated the penecontemporaneous age of the strata. Several formational names have been applied to these beds, some of which are: Escabrosa Limestone, Redwall Limestone, Roger Springs Limestone, Topache Limestone (?), Leadville Limestone, Gardner Limestone, Joana Limestone, and Madison Limestone. The equivalence of the Pavant section to these formations, at least in part, seems certain, and the position of the southern Pavant Mountains is such that any, of several, of these names could be applied. The Topache Limestone outcrops closer to the area under consideration than any other. Butler (1913, p. 35) described a thick section in the San Francisco Mountains and Earll (1957, p. 17) described a somewhat thinner section in the Mineral Range. Both of these workers, however, have reported that the formation is of Upper Mississippian age; nevertheless, compilers of the Geological Society of America Mississippian Correlation Tables (Weller, et. al., 1948) prefer a Lower Mississippian age for the formation and to have it equivalent to the other Lower Mississippian limestones of the Inter-Mountain region. Because of the problematical atmosphere surrounding the San Francisco and Mineral Mountain nomenclature, it seemed preferable to extend the name of Redwall from the south into the present area.

The thickness of the Redwall Limestone, measured at the southeast edge of White Sage Flat, is 273 feet.

PENNSYLVANIAN SYSTEM

Oquirrh Formation

Definition: Gilluly (1932, p. 34) applied the name of Oquirrh to a thick sequence of alternating limestones and quartzites aggregating 17,000 feet in the Oquirrh Mountains southwest of Salt Lake City. Dolomite and shale appear in the formation in subordinate amounts. The Oquirrh Formation served as host rock for mineralization surrounding the Bingham stock.

Distribution and lithology: The Oquirrh is the oldest formation

exposed in strata not affected by thrusting. Outcrops occur along the length of the hills extending from the east side of Dog Valley to Utah Highway 13 near Cove Fort. Exposures in the overturned fold extend from Dry Wash to Dog Valley.

A notable difference between the Oquirrh in the type locality and the present area is the subordinate amount of quartzite in the Pavant section. While quartzites occur near both the base and top, and some sandy beds are present in the middle of the formation, the total volume is not great.

Two massive limestone beds hold up prominent ridges in the Pavant Range. These consist of coarse crystalline, medium gray limestone which lithologically, are strikingly similar, but close inspection reveals two reddish-brown, lime-cemented quartzite beds in the lower unit, and the sparse occurrence of solitary corals in the upper unit. Two thick sequences of platy, dark gray limestone alternate with the massive beds. Several brown, sugary-textured dolomite strata occur. Erosion surfaces enclose the formation in the Pavant Range.

Age, correlation, and thickness: The base of the Oquirrh was drawn at the bottom of the first quartzite bed. Endothyroids below this datum and the occurrence of *Composita subtillita* and *Neospirifer cameratus* above indicate a long interval of non-deposition. Fusulinids occur at several horizons in the formation, but of a great many collected, none were identifiable. Rarely wall structures and fluting patterns are faintly preserved, but generally, recrystallization has destroyed all but outlines. By lithologic comparison of the Pavant section with sections that have been age-bracketed, and by application of fusulinid evidence, it is believed that the Morrowan, Derryan, and Desmoinesian epochs are represented in the Pavant Mountains.

It should be noted that a measured thickness of 949 feet in the south end of the Pavant Range shows a tremendous thinning from the reported 17,000 feet in the Oquirrh Range. In the Stansbury Mountains, west of the Oquirrh Range, the formation thins from 15,000 feet to 100 feet within a distance of 30 miles (Wright, in preparation). Thinning to the south is not so abrupt, but apparently shows the miogeosynclinal nature of the Pennsylvanian sediments in Utah.

PERMIAN SYSTEM

Pakoon Limestone

Definition: McNair (1951, p. 524) found a thick series of tan-gray dolomitic limestones beneath the Supai redbeds in southeastern Nevada. The Callville Limestone occupies this stratigraphic position in the Hurricane Cliffs 90 miles to the east. By lateral tracing McNair showed that the dolomitic limestone was a distinct lithic unit and formed a rapidly thinning wedge that pointed east out of Nevada. To this wedge of dolomitic limestone he applied the name Pakoon.

Distribution and lithology: The outcrop pattern of the Pakoon Limestone is similar to the Oquirrh Formation in the south end of the Pavant Range.

Small, transparent blebs of calcite pock-mark the tan weathering surface of the formation. The thin bedded light gray limestones are very dolomitic throughout, and commonly contain a large amount of silt. Orange-brown, lime-cemented quartzites are present at the base of the formation, and brachiopod-bearing yellow-brown shales occur at the top.

Age, correlation, and thickness: As no diagnostic fossils were found in the Pakoon its age is not definitely known. Assignment of these beds is made solely on the basis of lithologic similarity. The presence of a probable disconformity at the base of the sequence favors a Permian age rather than Upper Pennsylvanian. The age of the formation in the type locality is Wolfcampian, and without evidence to the contrary, the Pavant section is dated likewise. The Pakoon is 174 feet thick on the west ridge above Widemouth Canyon.

Coconino Sandstone

Definition: Darton (1910, pp. 21, 27) differentiated the Aubrey Group of Northern Arizona into the Kaibab Limestone, Coconino Sandstone, and Supai Formation in descending order. He proposed the name of Coconino for a thick, cliff-forming, cross-bedded, gray to white sandstone stratum that is very conspicuous in the walls of the Grand Canyon.

Distribution and lithology: The Coconino is exposed in the overturned fold extending from a point one mile south of the Kanosh cemetery to Dog Valley, and outcrops in normal position in the steep face of the mountain forming the east wall of Dog Valley. The vertical distribution of the sandstone is not constant as the formation forms a rapidly thinning wedge to the east. At the westernmost exposure, in Dog Valley, the formation is 288 feet thick, but thins to 30 feet before disappearing under the alluvium just south of the Kanosh cemetery.

The thinning of the formation is due more to depositional conditions than erosion. In the Dog Valley exposures the sandstone is homogeneous except for a grading from a somewhat friable rock at the base to quartzitic beds at the top; however toward the east, light gray intraformational limestones appear in the base of the formation until, at the last outcrop, it becomes difficult to distinguish between the Coconino and the subjacent Pakoon.

The typical Coconino in the Pavant Range is a yellow, cross-bedded and cross-laminated quartzitic sandstone. A few feet of beds at the base are a light red color, and pale reds and purples appear as streaks throughout the formation. The beds consist of clean, rounded, and well sorted quartz sand, and are very porous at some localities.

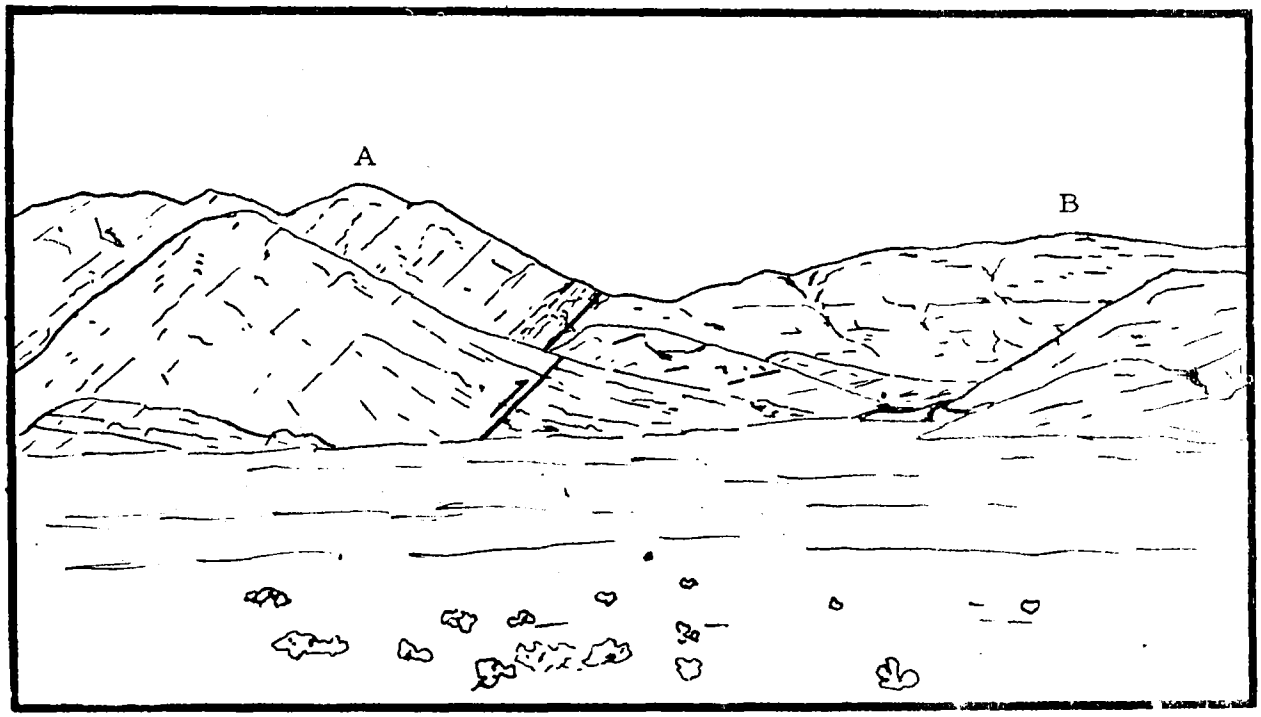


Fig. 2 View looking northeast across Dog Valley. Thrust fault plane underlying overturned limb of syncline shown by heavy line in saddle; (A), ridge held up by Kaibab Limestone; and (B), hill capped by Navajo Sandstone.

Age and correlation: The age of the unfossiliferous Coconino must be postulated from its position between beds of known age. A Leonardian fauna in the overlying Kaibab establishes a minimal age, but its maximum possible age is not as well defined. If the age of the Pakoon Limestone is Wolfcampian, as suggested above, then the Coconino is Late Wolfcampian or Early Leonardian. McNair (1951, p. 532) with reliable dating beneath the Coconino, prefers an Early Leonard age for the formation in northern Arizona.

Kaibab Limestone

Definition: The Kaibab Limestone was long known as the "Aubrey" Limestone, but when the US Geological Survey adopted the name of Aubrey for a group of Upper Carboniferous beds, the formation became the upper limestone member of this group. In 1910 Darton (p. 28) proposed the name Kaibab from the Kaibab Plateau which is capped by this upper limestone member. The Kaibab exposed in the Grand Canyon consist of massive, cherty, blue limestones alternating with thin beds of lemon-yellow limestones, shales, and sandstones.

Distribution and lithology: The Kaibab holds up the high ridge at the leading edge of the minor thrust which envolved the entire Paleozoic section (see Fig. 2). This ridge extends from near the mouth of Corn Creek to Dog Valley. The Kaibab caps

the mountain forming the east wall of Dog Valley, and at the north end, is in contact with overturned Kaibab. The formation outcrops briefly in Middle Canyon where it is the oldest unit exposed in a steeply plunging anticline.

A massive, light gray, coarse crystalline, skeletal-clastic limestone occurs at the base of the Kaibab, and is succeeded upward by a series of interstratified tan, silty sandstones, limestones and minor shales. Another thick to massive bedded limestone, similar to the basal unit, occurs above the sandy unit, and is, in turn, overlain by another unit of interstratified sands and limes. The Kaibab is characterized by the occurrence of bands of white to dark red chert, and some iron nodules appear in the tan sandstones.

Age, correlation, and thickness: The inclusion of fossils is perhaps the most distinctive feature of the Kaibab in the Pavant Range. Encrinite beds are common in the massive, crystalline limestones, and bryozoans reach biostromal quantities approximately 100 feet from the top of the formation. In several beds authigenic recrystallization has destroyed much of the fossil detail, but generally forms weather out and are well preserved for study. The following forms are part of a large collection:

Productus ivesi
Productus guadalupensis
Productus popei
Productus (?) *semireticulatus*
Hustedia meekana
Enteletes sp.
Derbya nasuta
Meristella sp.
Pugnax (?) sp.
Squamularia guadalupensis
Spirifer (?) *mexicanus*
Spirifer sp.
Fenestella sp.
Rhombopora sp.
Acanthocladia sp.
Streptosolen sp.
Euphemites sp.
Lophophyllidium sp.
Crinoid columnals

The above assemblage indicates an Upper Leonardian and Lower Guadalupian age for the Kaibab Limestone (Newell, et. al., 1953, see species tables in appendix). Girty (1908) earlier described a Guadalupian fauna from West Texas and reported many forms identical with those found in the Kaibab. The similarities of the two faunas makes temporal correlation possible; however the reef environment in West Texas during the Permian resulted in deposits differing lithologically from that of the Kaibab.

The lower half of the Park City Formation of northern Utah has been correlated with the Kaibab Limestone (Baker and Williams, 1940, p. 634), and the upper half of the Park City, which is referred to the Phosphoria Formation in southeastern Idaho, is considered to be younger.

With 1193 feet of beds the Kaibab is unusually thick in the Pavant Range. It is possible that the top of the Pavant section is equivalent to Phosphoria beds; however fossils found in the top of the Kaibab suggest that it is no younger than Wordian. Girty (1910) described a fossil assemblage from the phosphate beds of the Park City Formation which, individually and collectively, bear no resemblance to the Kaibab or West Texas faunas; however the uniqueness of the Park City fauna is generally ascribed to a phosphatic environment and should not necessarily rule out a similar age.

TRIASSIC SYSTEM

Moenkopi Formation

Definition: Powell (1876, p. 147) introduced the name Shinarump Group to include the later defined Moenkopi, Shinarump, and Chinle, and referred to the Moenkopi as the "Lower Portion". Gregory (1916, p. 79) first used the presently accepted term "Moenkopi" (see McKee, 1954, p. 4 for a history of the term).

The Moenkopi redbeds underlie much of the Colorado Plateau, and throughout much of its extent the formation can be divided into 5 members: the Lower Red member composed of deep red and brown siltstones and shales, the Virgin limestone member consisting of gray limestone and calcareous mudstone, the Middle Red member similar to the Lower Red member, the Shnabkaib member consisting of 4 to 10 foot light gray limestone and red siltstone interbeds, and the Upper Red member similar again to the Lower Red member.

Distribution and lithology: The Moenkopi is exposed in an overturned attitude in First Creek, Dry Wash, and Widemouth Canyons where it is deformed due to the compressional forces associated with thrusting. The formation is exposed over a large area in Middle Canyon where it forms a part of the north limb of a tightly folded anticline. Dog Valley Creek Canyon is formed on the easily eroded Moenkopi Formation.

The 5 members described above (Reeside and Bassler, 1922, p. 58) are well developed in the Pavant Mountains. The Lower Red member is thin however, but consist of typical red and brown irregularly laminated shales and siltstones. Iron nodules are locally abundant and a bed of thin paper shales occur near the top of this unit. The deep red color of this member contrast markedly with the light grays and yellow tans of the underlying Kaibab Limestone.

The Virgin limestone member is a series of dark brown-gray limestones interbedded with red siltstones and mudstones. This unit contains a *Meekoceras* fauna of which *Meekoceras gracilitalis* is dominant. The limestones are poorly bedded and tend to break in any random direction. Mudcracks and ripple marks occur in the shale beds.

The Middle Red member consists predominantly of red siltstones and shales, but several fine-grained, red sandstones occur. Ripple marks are again conspicuous and occasionally large nodules of dark reddish-gray hematite are observed.

The Shnabkaib member has five 10 to 15 foot light gray, crystalline limestone beds which are characteristically white speckled by the occurrence of star-shaped Pentacrinus whitei columnals. These five limestone beds are separated by thick beds of red sandstone and siltstone. Gypsum occurs as a cementing material in the siltstones in the upper part of this unit and weathers a powdery white which readily outlines its extent. Minor amounts of gypsum occurring in thin seams indicates its secondary origin.

The Upper Red member consist of red siltstones and sands. The top of this unit, and the formation, is marked by a bed of deep red mudstones which are silicious.

The depositional break at the base of the Moenkopi is everywhere paraconformable, but a change in color from light gray to brick red marks the boundary between the Paleozoic and Mesozoic eras.

Age, correlation, and thickness: The Meekoceras zone in the Virgin limestone member dates the lower part of the formation Lower Triassic (Smith, 1932), but nearly 900 feet of beds occur above this zone. Pentacrinus whitei occurs abundantly near the top, but dating within the Triassic period is not possible with this long-ranging form. A Tirolites zone was discovered about in the middle of the Moenkopi near St. George, Utah, and dates the containing beds upper Lower Triassic. Since approximately 1000 feet of beds are above this zone McKee believes that part of the Moenkopi must be of Medial Triassic age. A part of the Moenkopi in the Pavant Mountains is likely Middle Triassic since all members are well developed.

The Moenkopi was measured in Dog Valley. The formation is 1054 feet thick with the Middle Red member being the thickest.

Shinarump Conglomerate

Definition: When Powell named the Shinarump Group (1876, p. 54) he included beds both above and below a conglomerate formation which holds up the Shinarump cliffs in Kane County, Utah. While he did not differentiate the entire sequence, he used the name of Shinarump in a more restricted sense in referring only to the conglomeratic beds. His original definition describes only the grain size as he called the rock a "fine conglomerate".

Distribution and lithology: The extent of the Shinarump Conglomerate is similar to the Moenkopi except that it is not exposed in First Creek Canyon. The Shinarump is the youngest formation exposed in the overturned fold. The formation holds up a conspicuous ridge wherever it outcrops. The easily eroded

shales of the Chinle above and the Moenkopi below form strike valleys with the Shinarump between standing in a bold ridge. These ridges may be seen on the north side of Dog Valley, and in the Second Creek-Middle Canyon area the outcrop pattern is a large "V" opening to the southeast.

The formation consist mostly of gritstone with thin beds of chert pebble conglomerate occuring in "channels". The grits and sandstones are composed predominantly of vitreous quartz that weathers a light brownish-gray. Several purplish, friable sandstone lenses outcrop at the top of the formation interbedded locally with thin lenses of greenish-gray shale. Fossil wood is abundant throughout. The texture, cliff forming habit, and the inclusion of petrified wood makes this unit the best sequence marker in the Pavant Range.

The Shinarump rests conformably below the Chinle, and a basal conglomerate bed attests renewal of deposition on an erosion surface formed on the Moenkopi.

Age, correlation, and thickness: Except for petrified wood no fossils were found in the formation, and its age cannot be stated with certainty. Certain geologists feel that the Shinarump is a basal conglomerate to the Chinle and should be dated Upper Triassic (McKee, 1954, pp. 37-39). Stokes (1950) maintains that the formation is a fossil pediment, and was deposited and shaped by erosion during a long period possibly involving all of Middle Triassic. In many localities the overlying Chinle contains Late Triassic fossils which fixes the minimal age. The Pavant section is either Middle Triassic or Upper Triassic, or both.

Channeling and the emplacement of fossil wood clearly shows that the Shinarump is a fluviatile deposit. The thickness of the formation is 428 feet along the west side of Second Creek. This is considerably thicker than the 100 foot average for the Shinarump throughout most of the Colorado Plateau; however the conditions under which fluviatile sediments are laid down are such that an anomolous thickness poses little problem.

Chinle Formation

Definition: In 1917 Gregory (p. 42) formally proposed the name of Chinle for the group of "shales, marls, thin, soft sandstones, and limestone conglomerates" which rests between the Shinarump Conglomerate and Wingate Sandstone. Previous to 1917 Gregory had employed the term at least twice in literature. The formation was described from typical exposures in Chinle Valley in northeast Arizona where the formation exhibits variegated colors of red, lavender, chocolate brown, maroon and orange.

Distribution and lithology: The Chinle forms a slope above a ridge of Shinarump on the north side of Dog Valley and in Second Creek Canyon. There is also a brief exposure in Corn Creek Canyon 1 mile west of Big Spring.

Purple, coarse-grained sandstone resting on resistant tan-gray sandstone cliffs mark the base of the Chinle. Beds of variegated red, maroon, chocolate, and white mudstones which typically weathers to a deep red soil forms a retreat slope. Weak beds of purple and tan cross-bedded sandstone and variegated mudstone alternate in the upper half of the formation.

The thickness of the formation varies considerably. In Second Creek Canyon the beds measured 274 feet while 2 miles to the east no more than 50 feet of beds exist. The thinning of the unit is clearly an erosional feature as conspicuous beds of purple sandstone in the upper portion of the formation are missing in localities where the unit is thin. The amount of erosion suffered by the Chinle evidences the magnitude of the unconformity between the formation and the overlying Navajo.

Age and correlation: The Pavant section is similar in many respects to typical Chinle; although limestone conglomerates and the widespread volcanic ash does not occur. The Chinle beds are continuous with the Shinarump and are separated from the Navajo by an unconformity. These facts make it possible to assign the beds to the Chinle. Maxey (1946, p. 336) mapped these purplish beds as part of the Navajo, but noted the possibility of Chinle existing in the Pavant Range.

As far back as 1901, Lucas (p. 376) assigned the later defined Chinle beds to Upper Triassic on the basis of a reptilian fauna collected from outcrops in northeastern Arizona. More recently Paleontologists and especially Paleobotanists working with the floras of the Petrified Forest have substantiated the date. No fossils were found in the Pavant section and lacking evidence to the contrary the Chinle in this area is tentatively dated Upper Triassic.

JURASSIC SYSTEM

Navajo Sandstone

Definition: As in the case of the Chinle Formation, Gregory (1917, p. 57) formally adopted the term Navajo and defined it as the upper member of the La Plata Group after previously using the term in literature. In 1936 Baker, Dane, and Reeside redefined the Navajo and placed it in the Glen Canyon Group as the upper member above the Wingate and Kayenta sandstones. Gregory originally described the Navajo as a cliff-maker of red, cross-bedded, friable sandstone of uniform grain size.

Distribution and lithology: The Navajo Sandstone is widely distributed throughout the Pavant Mountains. In the area under consideration the formation is exposed from the mouth of Corn Creek to Big Spring where the Pavant overthrust covers it. A long "arm" extends into the center of the mapped area in the vicinity of Dog Valley.

In the Pavant Mountains the Navajo stands in steep cliffs. Some rounded forms and spalling, typical of the Navajo in the

more arid regions of southeast Utah and northern Arizona, are developed. Large cross-bedded patterns, more than 100 yards in length, are exposed on the canyon walls. The outcrops generally appear a desert red; however large outcrop patches appear white, expecially near the top. Maxey (1946, p. 337) suggests that these light-colored blotches may, in some way, be connected with the thrusting since the patches are more common near the fault plane at the top of the formation. Vertical streaks of dark brown stain the canyon walls where debris has washed over the steep cliffs.

The formation consist entirely of fine-grained quartz sand, and locally becomes extremely friable. Frosted surfaces on the rounded quartz grains are indicative of the eolian origin of the beds. In contrast to the formation in most localities, calcareous cement occurs only in minor amounts in the Pavant section.

Age, correlation, and thickness: No diagnostic fossils have been reported from the Navajo; none were found in the present area. Application of the term Navajo to the cliff-forming sandstones was determined by lighologic similarity and assignment to the Jurassic is made solev upon stratigraphic relationship outside the present area.

The thickest section exposed in the mapped area is 1742 feet, though 2019 feet has been reported from the outcrops east of Fillmore (Lautenschlager, 1952, p. 33). The top of the formation in the south end of the Pavant Range is an erosion surface on which the Cambrian thrust plate rests.

CRETACEOUS SYSTEM

Price River Formation

Definition: Spieker and Reeside (1925, p. 445) defined the Price River Formation from exposures in Price River Canyon. There the formation is divided into the Castlegate sandstone member and the upper member with both units consisting of medium-grained sandstone. Later work by Spieker (1946, p. 130) has shown that the exposures in Price River Canyon should not be considered typical. The formation becomes progressively finer-grained toward the Colorado border and progressively coarser-textured toward its origin just west of the Wasatch Plateau.

Distribution and lithology: The Price River conglomerates cover the Cambrian allochthon unconformably, and extend to the east beyond the mapped area where they are overlain conformably by the North Horn Formation. Beginning at Middle Canyon the Price River is exposed continuously on the west side of Second Creek to the head of that stream. A small patch of Price River caps the east side of a low ridge immediately northeast of Cove Fort. The conglomerate beds generally dip 15° to the east.

The formation is predominantly a sub-rounded cobble to boulder conglomerate with some fragments as large as 6 feet in

diameter. Clasts of Cambrian quartzites and limestones are easily identified, and were obviously derived from the thrust plate. The quartzite cobbles and boulders are cream to purple in color, and the limestone clasts are usually dark blue-gray. The massively bedded conglomerates are poorly sorted and moderately well consolidated. Sand, clay, and calcareous material cement the larger fragments.

Lenses of coarse sandstone are common and are undoubtedly channel sands of a creek or river. At least two light gray impure limestone beds outcrop in the mapped area.

The Price River conglomerates were deposited on an erosion surface developed on the Pavant thrust plate. Erosion was an active agent long enough to carry away all of the Mesozoic and Upper Paleozoic formations that must have made up part of the thrust plate. This erosion surface had a relief of at least 800 feet in the present area as shown by the position of the basal beds. The uniform dip of about 15° to the east from Corn Creek to the north end of the range near Scipio is considered sufficient reason for assuming that the beds have not been unduely distrubed since deposition.

The nature of the conglomerates and their uniform eastward dip in the central and northern portions of the range has led Lautenschlager to believe that the source of these conglomerates is from mountains not far to the west of the present Pavant Range (1954, p. 39).

Undoubtedly the source of the Price River conglomerates must have been within the area of the present range. Although Basin and Range faulting had not elevated the range to its present position, thrusting must have caused considerable relief, and if the Cambrian exposures west of Kanosh represent the root zone of the thrust, as it appears possible, then this relief was in the area of the present Pavant Range. Also, the cobbles in the Price River may be identified as Cambrian quartzites and limestones. This means then, that the thrust plate was in its present position and a thick sequence of Paleozoic and Mesozoic beds had eroded away before deposition of the Price River reached as far west as the eastern side of the present Pavant Range. The Cambrian elements of the thrust plate, now missing in the center of the range, may be found as clasts in the Price River Formation. Moreover, the attitude of the Price River is not uniform in the south end of the range, but dips bearing in several directions, even to the west, may be observed (see plate I). And, in general, these beds dip away from mountains that are presently in highest relief. That the beds dip away from their source seems the preferred interpretation since there is no evidence that the conglomerates have been unduely disturbed.

<u>Age</u>, <u>correlation</u>, <u>and</u> <u>thickness</u>: Since the conglomerate beds described in this section are conformably overlain by the North Horn Formation assignment to the Price River seems justified. Indianola conglomerates are overlain by Precambrian quartzites

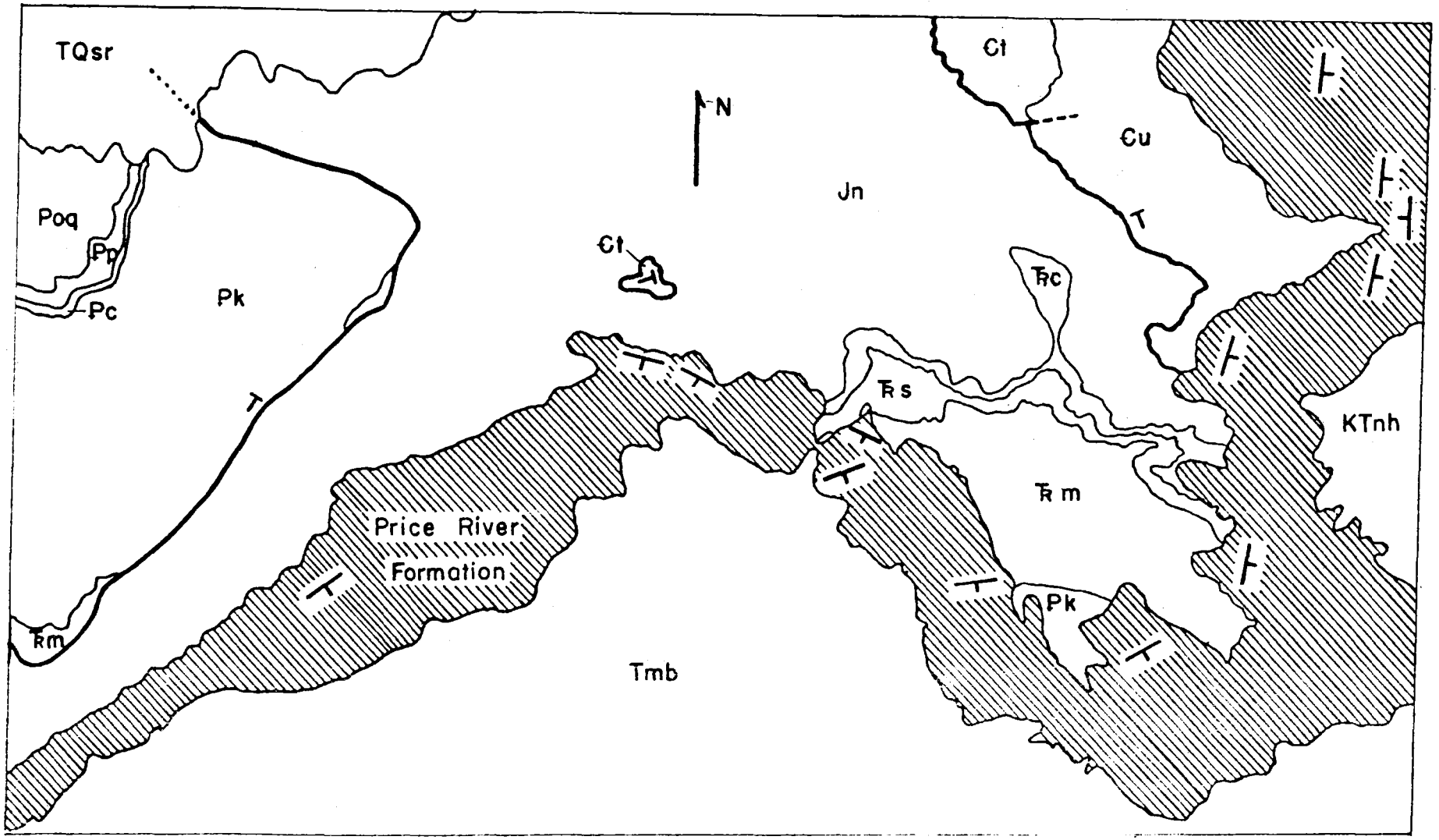


PLATE I

Map illustrating the attitude of the Price River conglomerates. Bedding planes slope away from the source area. Maximum dip is 22°.

in thrust relationship in the Canyon Range which is continuous with the Pavant Range. If the thrust faulting in both ranges is contemporaneous, and they logically resulted from the same compressional forces, then the conglomerates in the Pavant Range could not be assigned to Indianola.

Fossils collected by Spieker from Price River strata in the Wasatch Plateau date the formation in that locality as Late Montana. For the reason stated above it may be considered that the conglomerates nearest to the source are the youngest. The Price River in the present area could possibly be Early Lance.

The Price River in the Pavant Range is the edge of a depositional wedge, but thickens rapidly to the east. A section measured in Corn Creek Canyon at the eastern boundary of the map totaled 850 feet.

CRETACEOUS (?) AND TERTIARY SYSTEMS

North Horn Formation

Definition: In 1925 Spieker and Reeside (p. 448) divided the Wasatch Formation into the North Horn, Flagstaff, and Colton members. Spieker later (1946, p. 132) elevated these members to formational rank and restricted the North Horn to a series of fluviatile and lacustrine, red sandstones and shales below the fresh water limestone of the Flagstaff Formation. At the type locality on North Horn Mountain the formation consist essentially of flood-plain deposits of red and variegated shales and buff sandstones with monor beds of limestone.

Distribution and lithology: A depositional wedge of North Horn is exposed only briefly, and at a high elevation, on Trail Spring Bench along the eastern boundary of the mapped area. It outcrops extensively to the east and northeast in the range.

Only medium to coarse-grained reddish-brown sandstones and thin bedded brown-gray siltstones occur in the thin wedge outcropping in the present area, but shales and some limestones become common in the more representative sections to the northeast.

Age, correlation, and thickness: Since the discovery of reptilian bones in the lower part of the North Horn and mammalian bones in the upper part of the formation (Spieker, 1946, p. 134), it is now known that the North Horn spans systemic and era boundaries. A fresh water fauna collected by the same author substantiates the dating.

No fossils were found in the area under consideration; however it is possible that only the youngest beds of the North Horn occur; therefore only Tertiary equivalents may be represented in the North Horn exposed in the mapped area, but until additional evidence is brought to fore this cannot be stated definitely. Only 140 feet of North Horn beds are exposed in the mapped area.

TERTIARY AND QUATERNARY SYSTEMS

Sevier River Formation

Definition: Callaghan (1938, p. 101) applied the name of Sevier River to a series of fanglomerates, conglomerates, sands, and silts exposed as high level gravels in the Sevier River-Clear Creek area, which were derived mostly from the volcanic rocks of the Marysvale region.

Distribution and lithology: The Sevier River Formation is exposed over a large area between the town of Kanosh and the Pavant Mountains. At the southwest corner of White Sage Flat high level gravels of the Sevier River Formation are broken by recent faulting, and steep fault scarps expose the formation at the east side of Dog Valley.

The formation is an ancient pediment developed on the large fanglomerate deposits. The size of the clastic material, the nature of the bedding, and the attitude of the bedding clearly show that the sediments were laid down as large fans.

The outcrops in the south end of the Pavant Range occur near the foot of the mountains; hence boulder fanglomerate dominates the formation. The beds consist of poorly sorted clastic material ranging in size from silt to boulders 5 feet in diameter. Clasts of Tintic Quartzite, probably derived, in part, indirectly from the Price River Formation, are very common in the formation, although fragments from practically all formations found in the Pavant Range may be identified, including a high percentage of volcanic rock.

Age, correlation, and thickness: Callaghan traced beds of the Sevier River Formation on the east side of the Pavant Mountains several miles from Clear Creek to east of the Sevier River where they graded into lake beds containing diatoms and fresh-water gastropods. These forms proved to be sufficiently diagnostic to date the formation Upper Pliocene or Lower Pleistocene (1938, p. 101).

The pediment formed on the Sevier River Formation was later dissected, probably during the pluvial episodes of the ice age during Pleistocene. This agrees, at least, with Callaghan's dating. The age of the Sevier River has been used to good advantage in dating volcanic and structural events in the south end of the Pavant Range.

A true measurement of the formation was not possible since erosional agents have beveled the top of the beds. Ninety-two feet of sediments are exposed in a gravel quarry along US Highway 91 at the north end of Baker Canyon; however the base is not exposed at this locality. The thickness of the formation near the mouth of Corn Creek is estimated to be over 200 feet thick.

QUATERNARY SYSTEM

Alluvium

The Pavant Range, like other Basin and Range mountains, is "shoulder deep" in its own debris. Water wells east of Kanosh, drilled to a depth of 200 feet have penetrated basalts, but have not encountered bedrock. The C. H. Erickson well (Dennis, 1946, p. 87) near Holden, Utah bottomed in pre-Lake Bonneville lake beds below the Sevier River (?) Formation at 560 feet. The valley fill penetrated by the drill is composed of fluviatile, pluvial, and lacustrine deposits, of which Lake Bonneville sediments form only a thin veneer about 15 feet thick (Maxey, 1946, p. 343).

Recent alluvium aprons spread out from the base of the Pavant Range and surround low hills held up by the Sevier River Formation. These apron deposits dip gently away from the mountains toward the west. Where exposed by gullying, beds of poorly sorted silt, sand and conglomerate may be observed. Several miles from the foot of the mountains the alluvium becomes very fine-grained and a rich soil developes on which a variety of crops can be grown where water is available.

Bonneville lake beds may extend briefly into the mapped area; however recent gullying and farming operations have obscured the gravels and terraces. A bay bar and a low 8 foot cliff cut into the Sevier River gravels are well developed along the northern boundary of the mapped area just south of Kanosh. White Sage Flat is presently below the Bonneville level, but shore line features are absent. White Sage Flat, however, is a sag pond and only recently has exterior drainage developed for a part of it; thus it seems probable that lake waters never entered the Flat.

Mount Belknap Series

Definition: Kerr (1957, p. 24) applied the term Mount Belknap to a series of Late Tertiary (?) rhyolite flows, tuffs, and agglomerates in the Marysvale area. Callaghan had earlier termed these flow "Later Tertiary" volcanic rocks to distinguish them from an eroded Middle Tertiary (?) series of flows. Kerr found that the rhyolites could be mapped on the basis of a division into gray rhyolites and red rhyolites. Interbedded with the flows are patches of white agglomerates composed chiefly of crystals freed in the disentegration of rhyolite rock.

Distribution and lithology: Flows spreading north from the Marysvale volcanic center overlapped the south end of the Pavant Range, and now cover about a third of the mapped area. Gray rhyolites hold up the high ridge along the south border of the area, and are continuous from east of Rockwood Peak to west of Dog Valley. Red rhyolites rest on top of gray rhyolites in the mountain forming the south wall of Dog Valley.

Units of the Mount Belknap Series were not mapped, although

four volcanic types were recognized. Light gray to white weathering agglomerates are exposed in Second Creek Canyon and the upper reaches of Clear Creek. The rock consists mainly of groundmass materials and vitreous silicate minerals and to a lesser extent of dark minerals of which biotite predominates. Where undermined by streams, low hills of unconsolidated agglomerate slump into the stream cut forming long smooth slopes of fine-textured rhyolite fragments and minute mineral crystals. The outcrops along Second Creek are very near the leading edge of the flows and occur at the base of a thick sequence of rhyolites. Because of their position at the base it is possible that they originated by cooling more rapidly and the subsequent breaking up by overriding flows. The stratigraphic position of the Clear Creek agglomerates is not known, but the beds seem to have been formed by the more common eruptive phenomena.

The agglomerates exposed in road cuts along Utah Highway 13 in the upper reaches of Clear Creek grade to tuff. The road cuts appear a brilliant white due to weathering halos on glass shards. The outcrop is speckled salt and pepper fashion with minor amounts of dark minerals.

Quartz latite forms the back slope of the hill just north of Cove Fort. A dark groundmass gives the rock an almost black appearance which resembles basalt on casual inspection. Under the microscope the glassy groundmass exhibits flow lines that spread around euhedral crystals. The rock contains in excess of 15 percent quartz. Orthoclase and andesine occur in about equal amounts, augite is a minor accessory, and a notable amount of magnitite appears in thin section.

Light gray rhyolite makes up by far the largest portion of the Mount Belknap Series in the area under consideration. Several recurring flows can be seen in the walls of the canyons which dissect the thick sequence. Large boulders of light gray rhyolite with engulfed pebbles of darker blue-gray rhyolite occur frequently at the base of Mary's Nipple. The beds weatherer a dark gray to black, but the fresh surface is usually light gray flecked with dark mafic minerals. Petrographic analysis of two samples, taken from Mary's Nipple and Dog Valley, gave the following percentages:

Quartz	6%
Orthoclase	25%
Andesine (frequently zoned)	22%
Hornblende	10%
Biotite, Apatite, Chlorite	2%
Groundmass (fn-xln feldspars predominating)	35%

A zone of alteration roughly parallels the erosional edge of the volcanics. Aqueous solutions following fault planes penetrated the flows altering and locally mineralizing the zone.

The flows spread over an erosion surface that had cut

deeply into the Tertiary sedimentary sequence on the east slope of the Pavant Mountains exposing Mesozoic and Paleozoic strata. The oldest sedimentary beds in contact with the rhyolite are Pennsylvanian in age.

Age, correlation, and thickness: Radioactive dating of secondary uranium minerals in the Marysvale area gives an age of 10,000,000 years, and establishes the Pliocene as a minimal age for the containing Mount Belknap flows (Kerr, 1957, p. 197). The Sevier River Formation resting nonconformably on the rhyolite substantiates this dating.

The earlier volcanic series, the Bullion Canyon volcanics, spread over an erosion surface developed on a Tertiary sedimentary sequence, the youngest beds of which are probably Oligocene (Callaghan, 1938, p. 100 and Lautenschlager, 1952, p. 72). The Bullion Canyon volcanics were intruded by quartz monzonite north of Marysvale and then deeply eroded before the Mount Belknap Series erupted and spread over them. It would seem then that the Mount Belknap flows occurred sometimes during the interval between Mid-Oligocene and Mid-Pliocene.

The thickness of the Mount Belknap rhyolites exceeds 2000 feet just north of Marysvale. The series was not measured during the present study, but at least 2560 feet are exposed on the west face of Mary's Nipple.

Pavant Basalt

A long line of basalt flows now cover much of the floor of the Pavant Valley extending from Black Rock volcano west of Kanosh to the Pavant flow west of Holden. Three main flows occur: the Pavant flow notched at both the Bonneville and Provo lake levels, the Tabernacle flow notched only at the Provo level, and the Ice Springs flow exhibiting no shore line features. The Pavant flow is at the north end of the valley; however the flows west of Kanosh, at the south end of the valley, are here designated the Pavant flow since shore line features of both lake levels are visible.

Only a small erosional remnant of Pavant Basalt remains in the mapped area, although cones and craters associated with this flow form prominent landmarks just north of the boundary. The basalt is black and weathers a reddish-black. Vesicles are elongated and drawn out to points which clearly show the flow structure. Small lathes of andesine make up about 10 percent of the rock and augite occurs in minor amounts.

It is not known if the Alpine level of Lake Bonneville is present on Black Rock Volcano, but from evidence extant the flow pre-dates the lake. The basalts probably rest on Sevier River conglomerates though recent alluvium masks this relationship. The degree of weathering from youngest volcanics to oldest in the Pavant Valley changes only slightly; thus the age of the Pavant flow is probably Early Pleistocene.

STRUCTURE

GENERAL SETTING

Structural features on the west slope of the Pavant Range follow closely the structural pattern of most Basin ranges which are characterized by huge faulted blocks composed mostly of Paleozoic rocks that, prior to the time of block-faulting, had been closely folded and thrust-faulted. The Late Cretaceous-Tertiary sedimentary sequence on the east slope of the range exhibits relatively little structural complication with homoclinal folds and normal faulting fitting closely the simpler Plateau structural pattern. While an abrupt mountain face and disrupted bedding in the northern part of the range show typical Basin structure, the south end of the Pavant Mountains show these features less conspicuously because bedding in the overturned fold and the overthrust plate dips steeply into the valley where block faulting is concealed by alluvium.

PAVANT THRUST FAULT

The north-south trending trace of the Pavant thrust fault crops out on the west slope of the Pavant Range near its highest elevation. Exposures of the upper plate are continuous to the north as far as Holden, Utah. The thrust plate may have, at one time, been continuous with the thrust plate exposed in the Canyon Range to the north. In general, the white quartzites forming the sole of the thrust plate contrast markedly with red sandstones of the Navajo upon which it rest. The Tintic Quartzite, however, is cut out by thrusting south of Monk Spring and only Cambrian carbonates are exposed in the thrust plate. Maxey (1946, p. 353) explained the elimination of the Tintic on the basis of the relative competency between quartzite and limestone beds. His interpretation is followed here.

The dip of the fault is 21° east where the trace is exposed on the north wall of Corn Creek Canyon. On the south side of the same canyon the allochthon turns almost up on end and dips 65° to the north. Because of this abrupt change in attitude it appears probable that these exposures are the southernmost extension of the thrust plate, at least this far east. The Price River conglomerates, and younger formations, cover the allochthon and its eastern extent is not known.

The thrust plate is also exposed at the foot of the mountains 5 miles southwest of Kanosh, though the trace is concealed by subsequent normal faulting. These beds dip 45° north and strike east-west similar to those of the allochthon exposed on the south side of Corn Creek Canyon. The western exposures of the allochthon, consisting of Tintic Quartzite and Ophir Shale, are repeatedly cut by shear faults. The pattern of these faults indicate that this again is the southernmost extent of the thrust fault (see Fig. 3).

The Kaibab Limestone is the oldest exposed formation of the lower plate, and the Navajo Sandstone is the youngest. The thrust plate exposed along the high ridge of the mountains every-

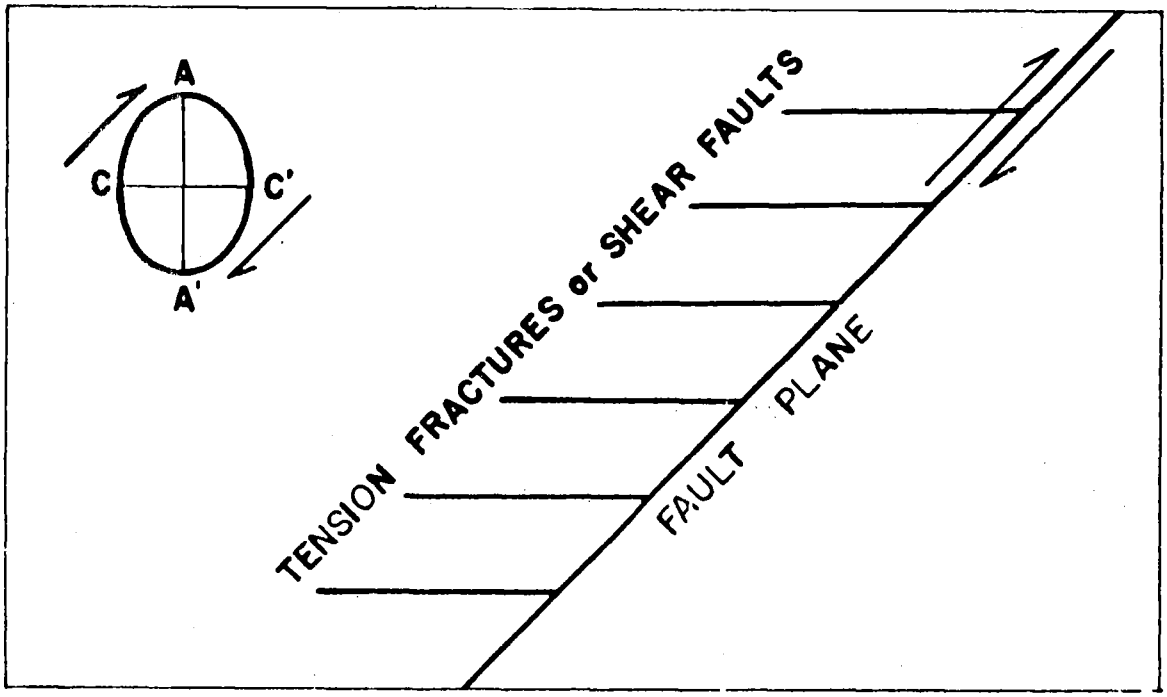


Fig. 3 Plan view of the fault trace along the edge of an overthrust plate showing tension fractures or shear faults developed at right angles to the greatest strain axis AA' on the strain ellipsoid.

where rests on the Navajo. There is a singular lack of contortion of strata both above and below the fault plane. The exposures west of Kanosh rest on various formations of the overturned fold. Imbrication in the overturned fold is very common, but only major ones were mapped.

During the thrusting event a large asymmetrical anticline and concomitant syncline developed. As the compressional force increased the beds ruptured through the trough of the syncline and moved a short distance, probably less than a mile, to the east and southeast. The beds subsequently ruptured through the crest of the anticline and moved a considerable distance to the east overriding the overturned limb of the syncline. Erosion later exposed the overturned Paleozoic strata (see Fig. 4). Thus the overturned Paleozoic beds were at first a drag fold developed during thrusting which subsequently became a part of the thrust as now evidenced by their resting on Mesozoic beds in thrust relationship.

Westernmost exposures of the Pavant thrust fault are 15 miles from those fartherest to the east. This sets a minimum displacement along the fault, but how far the allochthon extends under the Late Cretaceous-Tertiary beds is not known; however it is not present in the Sevier Plateau about 6 miles east of Richfield. The steep northwest dips of the Cambrian formations on the west side of the mountains suggests that the root zone of the thrust is in this locality, however conclusive proof of this possibility is lacking.

BLOCK DIAGRAM

showing the structural evolution of the Pavant Range

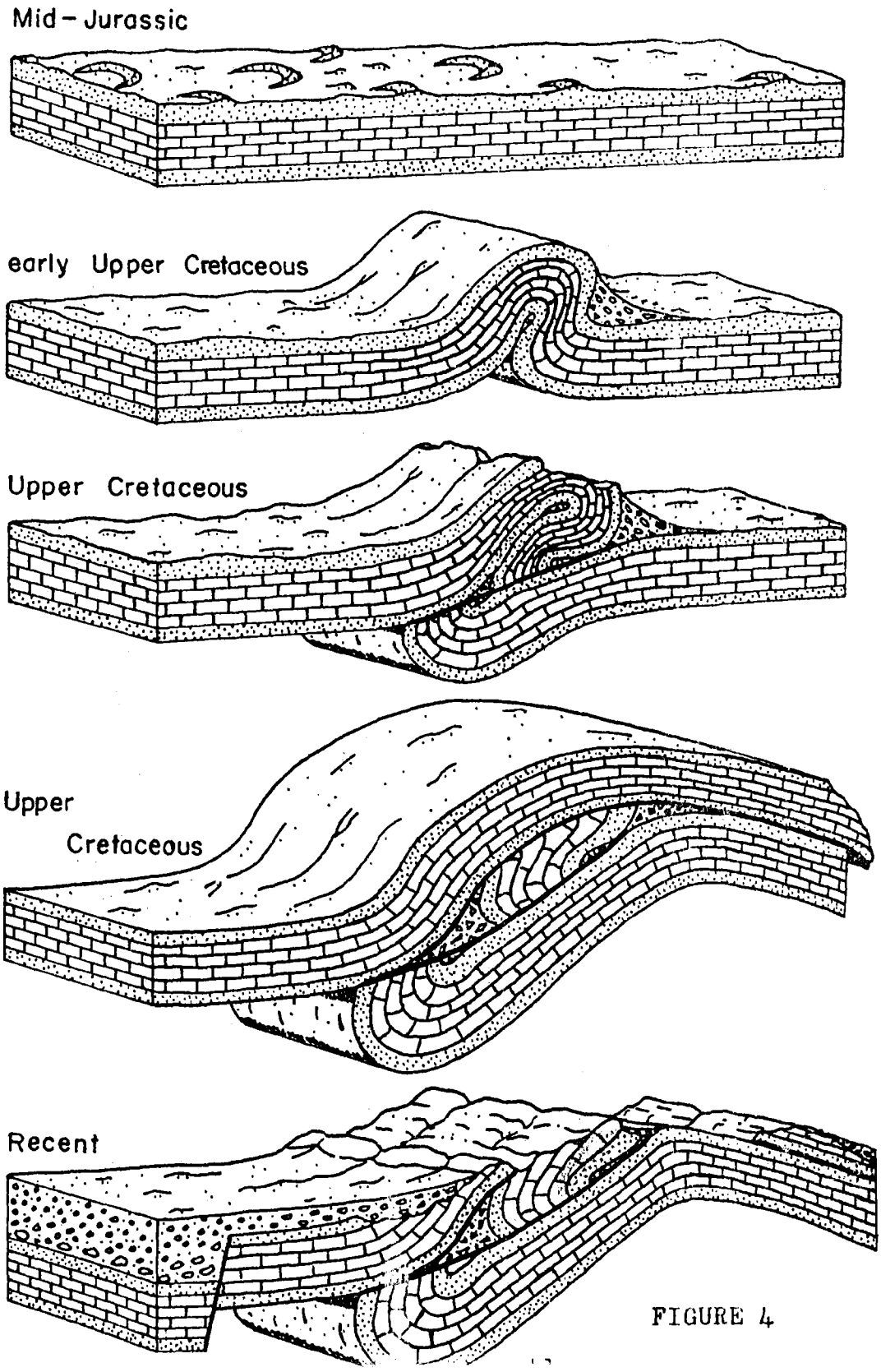


FIGURE 4

The approximate age of the Pavant thrust fault may be extrapolated from the position of the thrust plate between Lower and Middle Jurassic Navajo Sandstone and Upper Cretaceous Price River conglomerates, but a specific date is more difficult to obtain. A similar thrust plate in the Canyon Range (Christiansen, 1952, p. 731) places Precambrian and Cambrian quartzites on Indianola (?) conglomerates; a relation which dates the period of thrusting Upper Cretaceous. A similar date has been postulated for all major thrusts in western Utah and southeast Nevada (Miller, 1958).

Spieker (1946, p. 150) has presented evidence for a Mid-Cretaceous Orogeny which affected a broad zone from southeast Nevada through central Idaho. Local expression of this orogeny is found in the Indianola conglomerates in the Wasatch and Sevier Plateaus of central Utah. Coarse clastic material occurs at the base and again at the top of the formation with finer-grained marine sediments occurring between. The two conglomerate beds are considered evidence for dual pulses of the orogeny with strong folding associated with the earlier beds and folding and thrusting associated with the latter conglomerates; and indeed, these conditions obtain in the Canyon Range. The above facts do not point definitely to a Late Coloradian age of thrusting in the Pavant Range, but in the light of the above discussion such a conclusion seems warrented.

NORMAL FAULTS

Two periods of normal faulting are recognized in the south end of the Pavant Range. The first, and most important, may be allocated to Basin and Range block faulting of probable Miocene age. The second occurred in Quaternary time, but may have been continuous from an earlier period.

Evidence of normal faulting is extant on both sides of the range, especially in the south end. After relaxation of the compressional forces associated with thrusting, blocks on both sides of the Pavant subsided leaving the Pavant Range elevated as a horst. The Pavant Valley forms a broad graben with the block faulted Cricket Hills some 30 miles to the west. A graben probably exist to the southeast of the range, though a volcanic cover prohibits discernment.

The trace of the fault on the east side of the mountains is now covered by post-faulting volcanics, but its presence is postulated by an abrupt mountain face with disrupted bedding, deep V-shaped canyons, and a zone of alteration and mineralization paralleling the erosional edge of the rhyolite flows. This fault is considered to be of Miocene age corresponding with Basin and Range faulting, but since evidence of displacement of the Price River conglomerates is not completely lacking the fault may be much older. Stratigraphic throw cannot be ascertained, but it appears to be less severe than along the west face of the mountains.

Displacement along the west face of the mountains occurs

in several step faults with the major Basin and Range fault now concealed by alluvium. The abrupt mountain face resulting from such faulting, especially in the north end of the range, prompted Butler (1920, pl. 4) to map the northern extension of the Hurricane fault into this vicinity. At only one place, in a mine at the south edge of White Sage Flat, could the attitude of one of the step faults be determined, and there a strike of N. 57° E. and a dip of 45° N. was measured; however major displacement probably occurred along a plane which is considerably steeper. Total displacement could not be determined; however the highest point of the range stands approximately 5000 feet above the valley floor and the deepest well penetrates 560 feet of valley fill (Dennis, 1946, p. 87) without encountering bedrock; thus minimum displacement is 5560 feet.

From relations extant in the range the age of the faulting can be no better established than post-thrusting and pre-Sevier River - an interval spanning the entire Tertiary period, but structural similarities suggest that faulting in the Pavant Mountains was concurrent with other Basin ranges.

A zone of recent faulting occurs from White Sage Flat, through Dog Valley, and is continuous south of the mapped area. The recency of movement is attested by steep scarps occurring in the relatively unconsolidated Sevier River Formation, deep sag ponds formed along the fault trace, and late magmatic activity along the trace.

The faults are essentially parallel and strike approximately N. 10° E. Dip measurements on the faults were not possible, but the movement was probably not far from vertical. The zone extends for 8 miles in the mapped area, and one fault, north of Dog Valley, is continuous for at least 5 miles. The fault pattern strikes approximately perpendicular to the older set.

Both volcanics and Sevier River conglomerates are broken by this group of faults; it is apparent then, that part of the movement took place during Quaternary time. One fault, paralleling US Highway 91 approximately three quarters of a mile east of Baker Canyon, displaces beds 250 to 300 feet and is responsible for sag ponds in both Dog Valley and White Sage Flat. This fault has dropped the floor of White Sage Flat below the lake level during the Bonneville stage; yet no shore line features are visible; thus it may be concluded that movement was post-Lake Bonneville. Albeit, the lake may have entered White Sage Flat, but as a small protected finger of water with little cutting power.

FOLDS

Mesozoic and Paleozoic beds forming the authochthon are warped into a gentle anticline with its axis trending north-south throughout most of the Pavant Mountains, but at the south end these beds turn up giving northward dips up to 45°. At two places the strata may be observed to dip toward the south exposing a tightly folded anticline in Middle Canyon and a more

open fold in Dog Valley. The Dog Valley anticline is faulted. The axis of these folds are aligned, but are plunging in opposite directions. It appears that the fold axis is continuous between the two exposures with volcanics covering a depression and a culmination possibly occurring near the outcrops. Permian Kaibab is the oldest formation exposed in the Middle Canyon anticline and the Pennsylvanian Oquirrh forms the oldest exposure in Dog Valley.

The overturned limb of an asymmetric syncline has already been discussed in the section on thrusting; however brief mention should be made here of the fact that beds may be observed to overturn from 75° past vertical, to 180° in Baker Canyon.

The Late Cretaceous-Tertiary sedimentary sequence on the east slope of the range dips an average of 15° to the east. This dip considerably departs from any attitude that might reasonably be expected during deposition. Disturbance of these beds, however, is restricted to tilting with little, or no, attendant folding. Tilting is best explained by uplift of the mountains during Basin and Range faulting. If this is true, the foot wall moved up in fact, and not just relative to the hanging wall.

The rhyolite flows dip 10° to 15° toward the south. Since this is the direction of their source, a downwarping in the vicinity of Clear Creek Canyon is evidently the expression of a post-volcanic disturbance. The synclinal axis of the downwarp in Clear Creek Canyon roughly parallels the anticlinal axis between Middle Canyon and Dog Valley.

ECONOMIC GEOLOGY

Sulfur

The American Sulfur and Refining Company conducts mining and processing operations at Sulfurdale, Utah 6 miles south of the mapped area. Sulfurdale is perhaps the center of a mineralized area of considerable extent. Secondary mineralization is primarily controlled by faults. Commercial sulfur deposits occur in the area under consideration along faults on both sides of the low hills immediately to the northeast of Cove Fort. Sulfur in these deposits occurs in the native state encrusting country rock, but more commonly occurring as irregular masses and fine, poorly formed crystals imbedded in hydrothermally altered clays. The occurrence of sulfur in altered rhyolite and as crustations on Paleozoic limestones and cobbles of the Price River Formation clearly indicates a secondary origin. Moreover, water reaching the surface through seeps and hot springs at Sulfurdale is extremely acidic with a pH averaging 1½ (McIntosh, personal communication), and fluorine gas escapes from open cuts in sufficient quantities to be lethal to porcupines that unhappily wander into the prospects. A well recently drilled in Dog Valley to a depth of 960 feet produces water that gauges 196° fahrenheit at the surface. This gives additional evidence that mineralization is currently happening as well as being secondary.

Under present processes ore must be 20 percent sulfur to be of commercial grade. Several prospects in the area meet this requirement, but at the present time these deposits are being maintained as reserves by the American Sulfur and Refining Company, and mining activity is limited to diamond drilling to prove reserves and probe for additional ore bodies.

The quantity and the grade of the ore in the region of Sulfurdale, and the business atmosphere, has warrented the inauguration of a new program of development under which the American Sulfur and Refining Company will invest $2,000,000 in the near future (1959); and included in this program is the perfection of a new process of sulfuric acid manufacture which, it is hoped, will make poorer grades of ore commercial.

Fluorspar

Fluorspar, in minute amounts, frequently occurs as a gangue mineral with the sulfur, but locally exceeds 10 percent to be of commercial grade. A mine is presently being operated 1½ miles north of Cove Fort. During the present investigation a deposit of fluorspar was located on the rhyolite mountain at the south edge of Dog Valley where chalcedony and fluorspar occur in hydrothermally altered clay. The fluorspar in this deposit is an anomalous yellow-brown color. Under present conditions this deposit is probably not of commercial value.

The fluorspar deposits are probably genetically related to the igneous intrusions in the Tushar Mountains, and is presently being deposited as a vein mineral in fissures and fault

breccias. Fluorspar, deposited under parallel conditions, occurs in the Antelope Range near Marysvale (Buranek, 1951, p. 8).

Oil and Gas Possibilities

There are no surface indications of petroleum in the area. Good porosity characterizes the basal portions of the Coconino Sandstone and, since the formation forms a depositional wedge within the area, further investigation may be justified. Possible structural traps in the Dog Valley and Middle Canyon anticlines presently seems the most likely localities for prospecting. Faulting of the Dog Valley anticline has produced favorable conditions for oil and gas accumulation. While closure on the Middle Canyon anticline was not demonstrated during the present study such a condition appears probable from the known facts; moreover, almost the entire Paleozoic section lies beneath the oldest exposed formation, the Kaibab Limestone.

Other Products

The following list of additional economic products has, at one time or another, excited interest in the south end of the Pavant Range: gravel, building stone, uranium, lead, zinc, phosphate, iron, alunite, water, timber, and grasses. Undoubtedly other items should be included in this list as numerous "gopher holes" occur in the south end of the range, and just what the prospector was hoping to find is not always obvious. Several small but vivid red and yellow vesicular "gossan caps" occur in an altered zone that parallels the erosional edge of the volcanics. High scintillometer counts in the vicinity of the Shinarump Conglomerate resulted in the recent staking of almost every inch of outcrop, but as far as could be ascertained no commercial ore was ever taken from the Pavant Mountains. Of the above list, gravel, building stone, lead, zinc, water, timber, and grasses have been profitably exploited in the area under consideration.

SUMMARY OF GEOLOGIC HISTORY

The earliest geologic event recorded in the Pavant Range is the deposition of the Tintic sands in a transgressing sea. All Paleozoic sediments indicate that the Pavant area was slowly subsiding beneath a shallow sea at the edge of the Cordillerian miogeosyncline, generally under conditions favorable for marine plant and animal life, during this long period of time. Clastic sediments reflect brief withdrawals of the sea when the rate of sedimentation exceeded the rate of subsidence; but these depositional breaks were without apparent distortion of beds.

The redbeds of the Triassic and Jurassic systems were separated from Paleozoic sediments by a major unconformity, though without angular discordance. The formations were the product of a mixture of environments including shallow-sea, delta, eolian, playa, flood-plain, and probably various others. Most notable among this group is the sub-aerial sediments forming the Jurassic system; the Navajo Sandstone reflects thick deposition of dune sands under conditions of extreme aridity.

Compressional forces coming to bear during Late Colorado time caused major thrusting which repeated the Paleozoic-Mesozoic section in the Pavant area. In conjunction with relief created by thrusting, there was uplift and folding of older strata. Thousands of feet of pre-existing rock was worn away and deposited over a wide area to the east as the clastic sequence of the Price River Formation. The Early Laramide Orogeny contorted the beds into anticlines and synclines in the south end of the Pavant Range.

During Early Tertiary time eastern Utah was the site of large fresh water lakes, and lacustrine, fluviatile, and paludal sediments of this stage lapped upon the eastern slope of the "ancestral Pavant Mountains". Minor normal faulting and monoclinal flexing occurred near the end of this depositional interval, probably during Late Eocene and Early Oligocene. Major normal faulting, beginning in Miocene time, lifted the mountains to near their present elevation, tilting the Late Cretaceous-Early Tertiary sediments, and giving the range its present shape.

During Middle and Late Tertiary time volcanic activity in the Marysvale area was marked by flows, pyroclastic deposition, and intrusions of quartz monzonite. Flows of the Mount Belknap Series covered a large area in the southern Pavant Mountains.

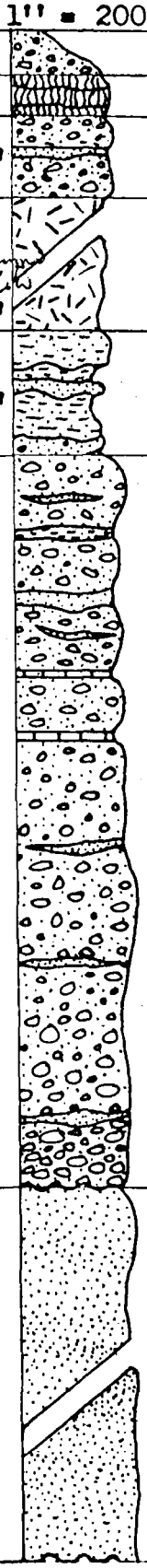
The Sevier River conglomerates evidence a pluvial environment in which coarse clastic material was deposited by torrential runoff. Gentle warping in Early Pleistocene time affected both volcanics and Sevier River conglomerates. Later in Pleistocene time there was periodic glacial activity in the highlands both north and south of the present area, and Lake Bonneville, on the west side of the range, fluctuated with glacial conditions. Since the lake receded there has been continued erosion in the mountains and deposition in the valleys.

APPENDIX

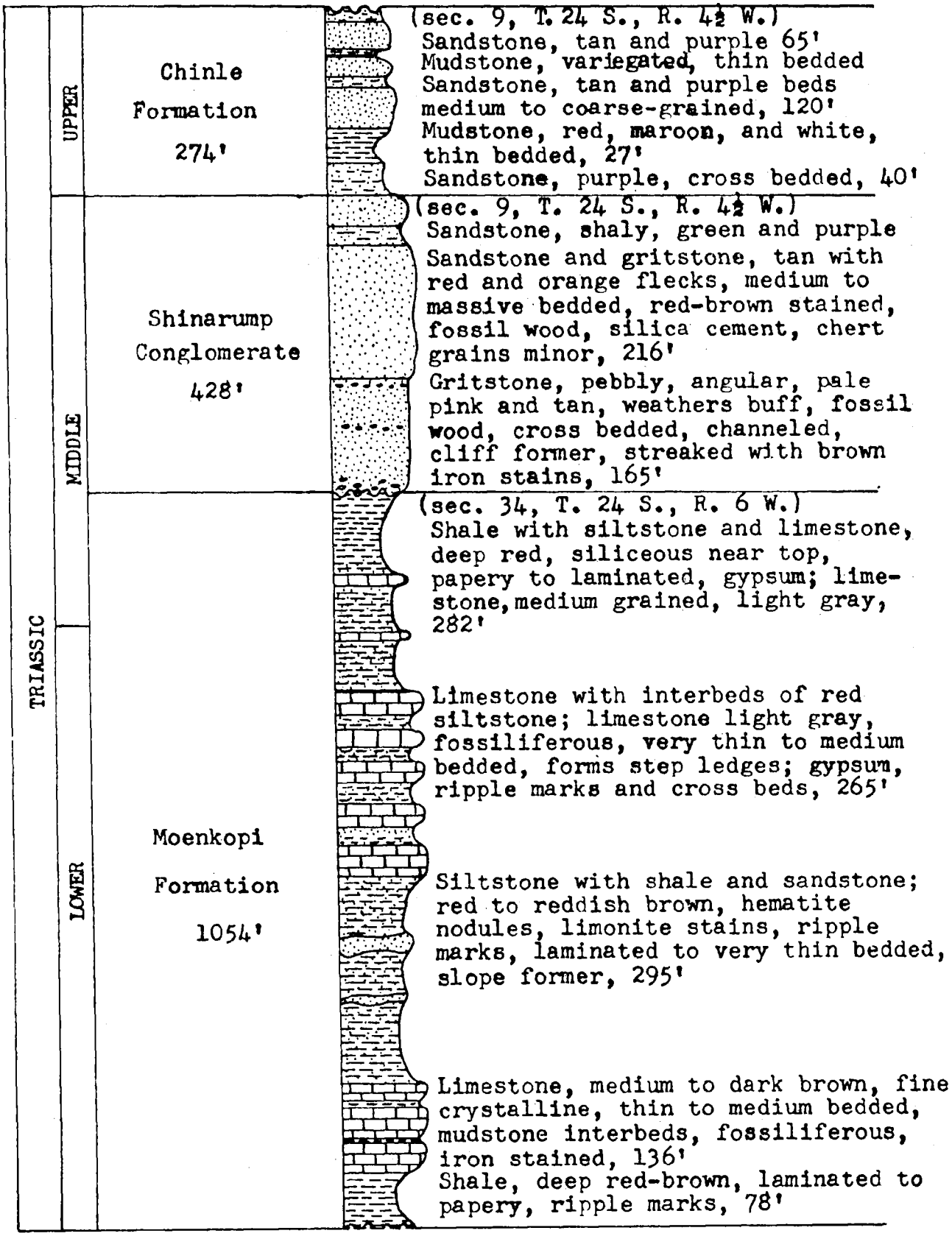
EROSIONAL COLUMN AND MEASURED SECTIONS

OF THE STRATIGRAPHY OF THE SOUTH PAVANT RANGE

1" = 200'



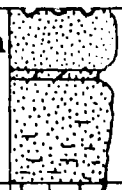
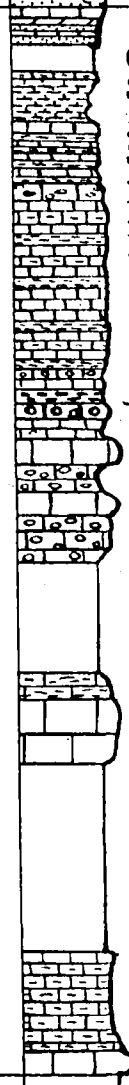
QUAT	R	Alluvium	Silt, sand, and gravel
QUAT	PLEIS	Pavant Basalt	Reddish-black vesicular basalt
QUAT	PLEIS	Sevier River Formation 92'	Cross-bedded cobble conglomerate Sand and clay, poorly sorted Boulder conglomerate, unconsolid.
TERTIARY	MID & LATE	Mount Belknap Series (of Bullion Canyon & Dry Hollow) 2560'	Rhyolite, quartz latite, tuff, and agglomerate. Light gray, dark weathering, Mineral crystals 2 to 5 mm in length.
TERTIARY	PALEO	North Horn Formation 140'	(sec. 1, T. 24 S., R. 4½ W.) Siltstone and sandstone, light red, cross-bedded, channeled, cliff former.
CRETACEOUS	UPPER	Price River Formation 850'	(sec. 1, T. 24 S., R. 4½ W.) Conglomerate with sandstone lenses pebble to cobble size, white and purple clasts, sand and silt matrix, well consolidated, massive, 246' Limestone, light gray, algal ball Conglomerate, dark purplish-red 95' Limestone, light gray, algal ball Conglomerate with sandstone lenses, white, pink, and purple quartzite, red sandstone, and dark gray limestone cobbles; sand and silt matrix, poorly sorted, well indurated, cobbles sub-rounded, moderate cliff former, 273' Boulder conglomerate, weathers dark reddish-brown, 88'
JURASSIC		Navajo Sandstone 1742'	(sec. 4, T. 24 S., R. 4½ W.) Sandstone, light red to brick red; fine to medium-grained, vitreous quartz grains rounded and frosted, massive beds, massively cross-bedded, excellently sorted, cliff former.


TRIASSIC
UPPER
MIDDLE
LOWER
Chinle Formation 274'
Shinarump Conglomerate 428'
Moenkopi Formation 1054'
(sec. 9, T. 24 S., R. 4½ W.)
Sandstone, tan and purple 65'
Mudstone, variegated, thin bedded
Sandstone, tan and purple beds medium to coarse-grained, 120'
Mudstone, red, maroon, and white, thin bedded, 27'
Sandstone, purple, cross bedded, 40'
(sec. 9, T. 24 S., R. 4½ W.)
Sandstone, shaly, green and purple
Sandstone and gritstone, tan with red and orange flecks, medium to massive bedded, red-brown stained, fossil wood, silica cement, chert grains minor, 216'
Gritstone, pebbly, angular, pale pink and tan, weathers buff, fossil wood, cross bedded, channeled, cliff former, streaked with brown iron stains, 165'
(sec. 34, T. 24 S., R. 6 W.)
Shale with siltstone and limestone, deep red, siliceous near top, papery to laminated, gypsum; limestone, medium grained, light gray, 282'
Limestone with interbeds of red siltstone; limestone light gray, fossiliferous, very thin to medium bedded, forms step ledges; gypsum, ripple marks and cross beds, 265'
Siltstone with shale and sandstone; red to reddish brown, hematite nodules, limonite stains, ripple marks, laminated to very thin bedded, slope former, 295'
Limestone, medium to dark brown, fine crystalline, thin to medium bedded, mudstone interbeds, fossiliferous, iron stained, 136'
Shale, deep red-brown, laminated to papery, ripple marks, 78'

PERMIAN	GUADALUPIAN	Kaibab Limestone 1193'	(sec. 28, T. 24 S., R. 6 W.) Limestone with silt and sand interbeds, gray to lemon yellow, 110' Limestone, light gray, weathers light to medium gray, coarse crystalline, medium to massive bedded, splits blocky, forms ridges or prominent step ledges, fossiliferous, nodular and banded chert, 322' Limestone with silt and sand interbeds; limestone light gray to medium brown; sand and silt tan to yellow-brown, friable, minor cross-bedding and channeling, minor clay beds; chert in limestone; one 12' bed of limestone intraformational conglomerate, 375' Limestone, light gray, skeletal-detrital, coarse crystalline, white to reddish-purple nodular and banded chert, encrinite forms lower half; medium to massive bedded, somewhat cavernous due to solution phenomena; several minor quartzite beds, 386'
	LEONARDIAN	Coconino ? Sandstone 288'	(sec. 31, T. 24 S., R. 6 W.) Sandstone, yellow tan, thin to medium bedded, brown and purple streaks show cross-bedding, quartzitic near top, porous, grains rounded and well sorted, 248' Limestone, intraformational, 24' Sandstone, red, friable, 16'
	WOLFCAMPIAN	Pakoon Limestone 174'	(sec. 21, T. 24 S., R. 6 W.) Limestone, dolomitic, silty, tan-gray, weathers tan, numerous transparent calcite blebs, thin bedded, yellow shale at top, orange-brown quartzite.

PENNSYLVANIAN	DESMOINESIAN	Oquirrh Formation 949'	(sec. 30, T. 24 S., R. 6 W.) Limestone, medium blue-gray, silty, platy, two orange-brown quartzite beds, fossiliferous, 143' Limestone, dark blue-gray, weathers medium gray, medium to massive bedded, banded black "false" chert, cliff former, 140' Quartzite and limestone, gray, 32' Limestone, dark gray, platy, 48' Dolomite, brown, massive, 18' Limestone, dark blue-gray, argillaceous material weathers tan, platy, slope former, 190' Dolomite, medium brown, sugary-textured, sandy, 54' Limestone, blue-gray, platy, 82'
PENNSYLVANIAN	DERRYAN	Oquirrh Formation 949'	Limestone, medium gray, finely crystalline, massive, two thin gray quartzite beds, ridge former, 158'
PENNSYLVANIAN	MORROWAN	Oquirrh Formation 949'	Limestone, medium gray, weathers light to medium gray, medium crystalline, thin bedded, fossiliferous, 150' Quartzite, reddish-gray, coarse, 34'
MISSISSIPPIAN	LOWER	Redwall Limestone 273'	(sec. 16, T. 24 S., R. 6 W.) Limestone, oolitic, encrinite beds at top, medium gray with orange-brown flecks, weathers with a reddish cast; coarse crystalline in lower half, silty toward top, medium bedded with faint laminations, forms step ledges, banded red chert, fossiliferous.
DEVONIAN	U	Cove Fort Quartzite 83'	(sec. 16, T. 24 S., R. 6 W.) Quartzite, cream, massive.
DEVONIAN	MIDDLE	Guilmette Formation 570'	(sec. 16, T. 24 S., R. 6 W.) Dolomite, dark gray, weathers brown. Protoquartzite, red-brown, 8' Dolomite with limestone, dark gray to black, calcite stringers, thin to medium bedded, medium-grained, Olive shale float near base of unit, forms slope with minor step ledges, 216' Protoquartzite, red-brown 6' Dolomite, medium to dark gray, algal structures, medium bedded, 163' Dolomite intraformational breccia. Dolomite, light brownish-gray, laminated, quartzite, shale, and limestone.

DEVONIAN	MIDDLE	Simonson Dolomite 239'	(sec. 16, T. 24 S., R. 6 W.) Dolomite, dark gray, weathers deep reddish-brown, white calcite filaments, fine-grained, light gray and laminated near top, sugary-textured on surface, thin to medium bedded, forms gentle slope.
		Sevy Dolomite 673'	(sec. 9, 16, T. 24 S., R. 6 W.) Dolomite, light gray, finely crystalline, minor chert nodules, thin bedded, 187'
			Dolomite, dull medium gray, weathers white to very light gray, aphanic, subconchoidal fracture, dense, contains 8.7 percent bentonitic clay, very thin bedded, forms retreating slope, 321'
			Dolomite, light gray, finely crystalline, thin bedded, 165'
S ?		Fish Haven Dolomite 1000'	(sec. 25, 36, T. 24 S., R. 7 W.) Dolomite, Medium gray, 82'
ORDOVICIAN	UPPER		Dolomite, dark gray, with purple cast, weathers dark chocolate gray, finely crystalline, thick to massive bedded, locally contains 50 percent chert in bands, nodules, and stringers, algal structures exceedingly abundant, weathers with rough and gnarly surface, with minor beds of intraformational conglomerate, forms prominent ridge, fossiliferous, 506'
			Covered, 198'
			Dolomite, same as unit above only with laminations, 212'
			Dolomite, sandy, 2'

ORDOVICIAN	MIDDLE	Swan Peak-Eureka Quartzite 178'		(sec. 25, T. 24 S., R. 7 W.) Quartzite, white with purple streaks, highly indurated, clean vitreous quartz grains, thin sandy dolomite unit, brown protoquartzite at base.
	LOWER	Pogonip Limestone 1110'		(sec. 24, 25, T. 24 S., R. 7 W.) Covered, protoquartzite float, 34' Shale, olive brown with thin dark gray limestone interbeds, 55' Same as above with more limestone, 61' Limestone, Medium gray with slight reddish tint, weathers light gray, thin olive brown shale beds alternate, clastic, bedding irregular, several intraformational conglomerate beds, forms irregular slope, fossiliferous, 286' Limestone, gray, crystalline, 22' Limestone, intraformational conglomerate, silty and argillaceous, light gray, thin to massive bedding, 128' Covered, silty and argillaceous limestone, 116' Calsilutite, yellow-brown, 34' Limestone, medium gray, thick to massive bedding, crystalline, 50' Covered, silty and argillaceous limestone, 193' Limestone, silty and argillaceous, medium gray, weathers light brown gray, mud cracks, fossiliferous, 97' Limestone, gray, massive, 20'
CAMBRIAN	UPPER	Dolomite and Limestone		Covered

CAMBRIAN	MIDDLE	Herkimer-Bluebird-Cole Canyon Dolomites 1153'	(sec. 34, T. 23 S., R. 4½ W.) Limestone, dark blue-gray, weathers with a tan argillaceous "cloud", silty, finely crystalline, thin to medium bedded, weathers with knobby surface, forms retreating slope with minor step ledges, thin coquina bed near top; top of unit covered, 390'
			Shale, light brown, laminated, fissile, with limestone interbeds, 65'
			Dolomite, light gray, medium crystalline, thick to massively bedded, white calcite or dolomite stringers, with thin bedded limestone units, forms a series of massive ledges, 304'
			Dolomite and limestone, alternating; dolomite, light gray, medium crystalline, thick bedded; limestone, dark blue-gray with abundant white calcite stringers, medium bedded, 282'
			Limestone, dark gray, weathers with a reddish cast, and red flecks on fresh surface, dolomitic interbeds, 112'
		Dagmar Limestone 104'	(sec. 34, T. 23 S., R. 4½ W.) Dolomite, light gray, medium crystalline, massive, cliff former.
		Teutonic Limestone 424'	(sec. 34, T. 23 S., R. 4½ W.) Limestone, dark blue-gray, weathers dark gray, white and reddish calcite veinlets, silty, thin to thick bedded, slabby splitting, finely crystalline to aphanic, forms step ledges, contacts sharp.

CAMBRIAN	MIDDLE	Ophir Formation 418'	(sec. 4, T. 24 S., R. 6 W.) Limestone, algal, black; shale, olive. Limestone, dolomitic, red, silty, 22' Limestone and shale; limestone dark gray with orange and red blotches, crystalline, silty, thin to medium bedded; shale, steel gray, papery, irregularly bedded, forms slopes; unit fossiliferous, 250' Limestone, dolomitic, red, silty, 28'
	LOWER	Tintic Quartzite 1293' +	(sec. 4, T. 24 S., R. 6 W.) Quartzite, with green phyllitic shale interbeds, 80' Quartzite, grayish-white with pink and red beds, weathers cream-white with red and brown iron stains, highly indurated, almost pure quartz grains with occasional grains of chert, usually massive bedded, blocky splitting, several thin beds of pebble conglomerate, forms retreating ledges; base covered. Quartzite, deep purple, massive, 22'

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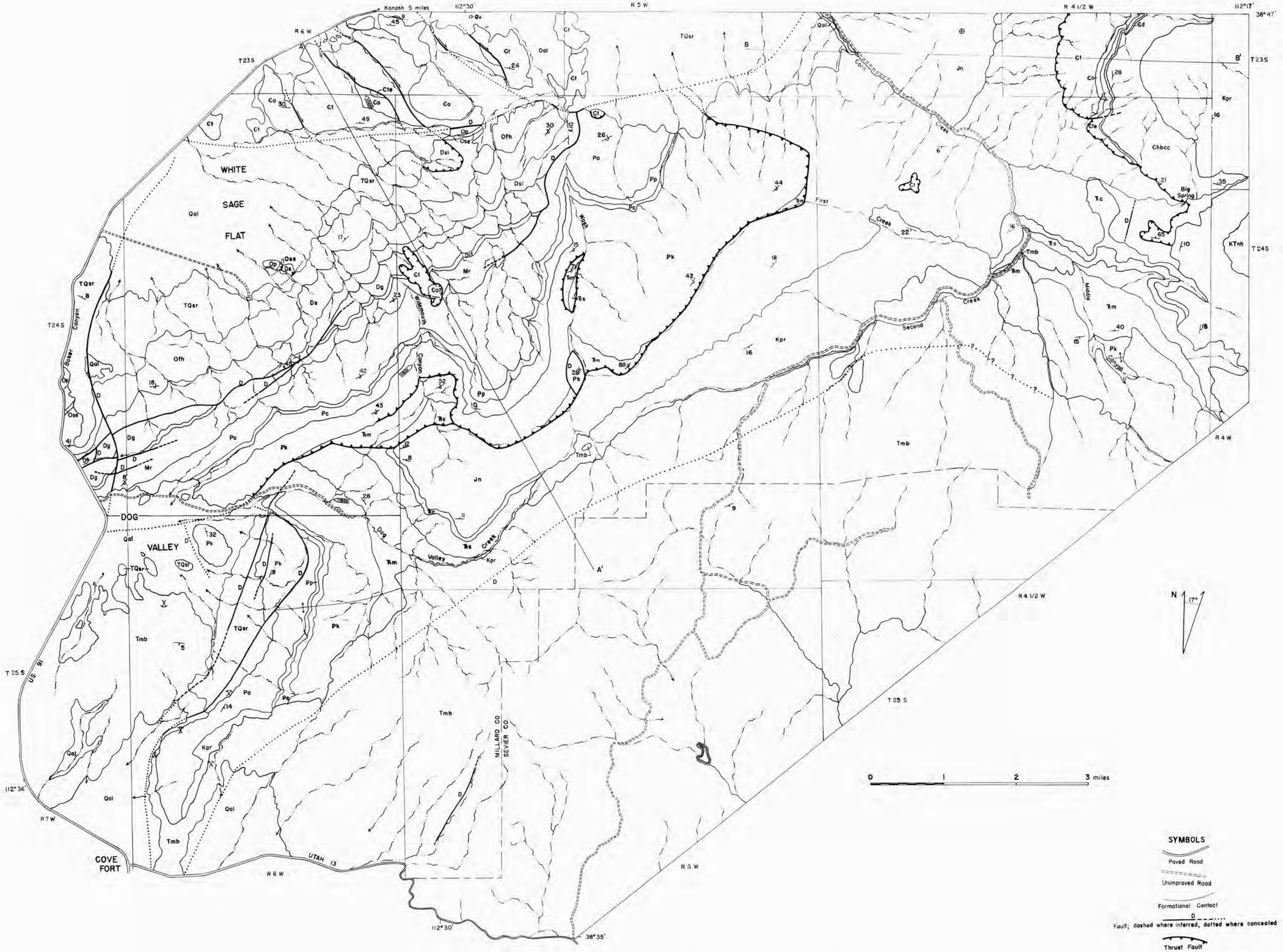
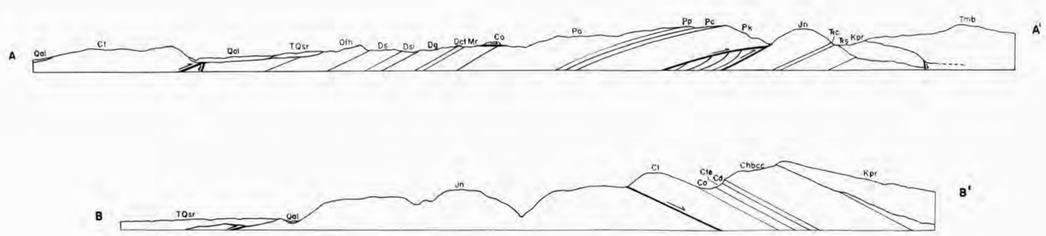
PLATE II





GEOLOGY AND CROSS SECTIONS OF THE SOUTH PAVANT RANGE MILLARD AND SEVIER COUNTIES, UTAH

by
Gary W. Crosby
1959

EXPLANATION

SEDIMENTARY ROCKS

QUATERNARY
- Qal — Alluvium

TERTIARY
- TQsr — Sevier River Formation

CRETACEOUS
- KTnh — North Horn Formation
- Kpr — Price River Formation

UNCONFORMITY

JURASSIC
- Jn — Navajo Sandstone

UNCONFORMITY

TRIASSIC
- Ꞧc — Chinle Formation
- Ꞧs — Shinarump Conglomerate

UNCONFORMITY

- Ꞧm — Moenkopi Formation

PERMIAN
- Pk — Kaibab Limestone
- Pc — Coconino Sandstone

PENNSYLVANIAN
- Pp — Pakoon Limestone

UNCONFORMITY

MISSISSIPPIAN
- Po — Oquirrh Formation

UNCONFORMITY

- Mr — Redwall Limestone

UNCONFORMITY

DEVONIAN
- Dcf — Cove Fort Quartzite
- Dg — Guilmette Formation
- Dsi — Simonson Dolomite

SILURIAN
- Ds — Sevy Dolomite

UNCONFORMITY

ORDOVICIAN
- Ofh — Fish Haven Dolomite

UNCONFORMITY

- Ose — Swan Peak-Eureka Quartzite
- Op — Pogonip Limestone

CAMBRIAN
- Chbcc — Herkimer-Bluebird-Cole Canyon Formations
- Cd — Dagmar Limestone
- Cte — Teutonic Limestone
- Co — Ophir Formation
- Cl — Tintic Quartzite

IGNEOUS ROCKS

QUATERNARY
- Qv — Pavant Basalt

TERTIARY
- Tmb — Mount Belknap Series

SYMBOLS

- Paved Road
- Unimproved Road
- Formational Contact
- Fault; dashed where inferred, dotted where concealed
- Thrust Fault
- 10 — Strike and Dip
- 80 — Overturned Beds
- Vertical Beds
- Horizontal Beds
- 20 — Fault Plane Attitude
- Sulfur Prospect
- Fluorspar Prospect
- Lead and Zinc Prospect
- Spring
- Anticlinal Axis
- 11000 — Fossil Locality