ABSTRACT

Geology and Mineralization of the Southeastern

Part of the Black Pine Mountains,

Cassia County, Idaho

by

Don E. French, Master of Science

Utah State University, 1975

Major Professor: Dr. Donald R. Olsen
Department: Geology

The southeastern part of the Black Pine Mountains is located in the southeastern part of Cassia County, southern Idaho. The Utah-Idaho state line is three miles south of the studied area and the Cassia-Oneida county line bounds it on the east. The area is nearly square and encompasses about 30 square miles.

Devonian, Mississippian, Pennsylvanian, Permian, Tertiary and Quaternary sedimentary rocks are exposed within the area. Limestone, dolomitic limestone, quartzite, and bedded chert represent the Jefferson (?) Formation of Devonian age. It is 400 feet thick, however, the base is not exposed. The Milligen Formation is Early Mississippian in age and is black argillite with interbedded orthoquartzite. The Milligen is about 1,850 feet thick. The Late Mississippian White Knob Formation is 2,400 feet thick and has two members. The lower member is limestone interbedded with calcareous siltstone. Massive blue-gray limestone with some chert nodules characterizes the upper member.

The undifferentiated Pennsylvanian-Permian unit is 1,800 feet of mostly sandy limestone. Quartzite and calcareous sandstone are also present. Tertiary rocks are present in the form of an orangish-white tuff which is considered part of the Salt Lake Formation. Lake Bonneville Group, alluvial, and landslide deposits represent the Quaternary System. Most of these are unconsolidated silt, sand, and gravel deposits. However, the Lake Bonneville Group displays a tightly cemented shore-line deposit in places.

The effects of metamorphism are common in the area. The Milligen shows signs of contact and tectonic metamorphism. In places it has been bleached or altered to slate and phyllite. The White Knob Formation has been marblized at several locations.

Igneous activity has emplaced two small dikes on the eastern flank of the Black Pine Mountains. Although they are highly altered, the original rock was apparently a diabase.

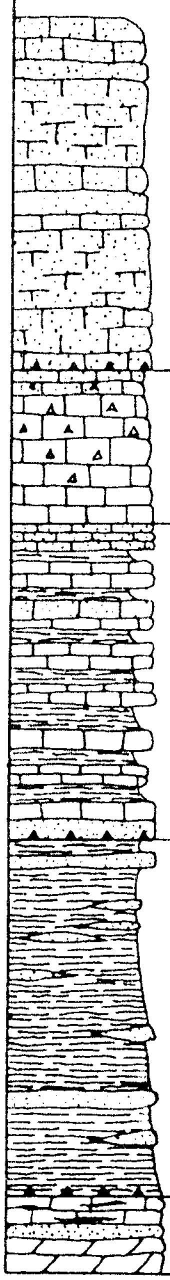
The structure of the area is complex. Three low-angle thrust faults are present which are generally situated along bedding planes. The lower thrust fault separates the Jefferson (?) and Milligen formations. The middle thrust fault intervenes at the Milligen-White Knob contact. Locally, this thrust fault has cut out the lower member of the White Knob. The upper thrust fault is present at the base of the undifferentiated Pennsylvanian-Permian strata. The upper thrust fault overlies the White Knob and, locally, the Milligen. Several high-angle faults are present which displace the low-angle thrust faults. A

major range-front fault is present on the southeastern side of the range. Displacement on it may be as much as 6,500 feet.

Mineralization in the area occurred during two episodes. The first was guided by fractures related to Laramide structure. This episode was characterized by mesothermal deposits of sphalerite, tetrahedrite, and jamesonite. Following the first mineral deposition Basin-and-Range faulting began. New fractures provided a locus for mesothermal and epithermal deposits of the second episode. Calcite, barite, and gold were deposited at this time. Emplantation of the dikes probably accompanied this episode.

(81 pages)

Table 1. Generalized stratigraphic section of the southeastern part of the Black Pine Mountains.



Lithology	Thickness (in feet)
Pennsylvanian and Permian Systems	
Undifferentiated Pennsylvanian-Permian unit. Light- to dark-gray, fine- to very fine-grained, sandy limestone and calcareous sandstone interbedded with grayish-brown to reddish-gray orthoquartzite.	1,800
upper thrust fault[a]	
Mississippian System	
White Knob Formation	
Upper member. Blue-gray, very finely crystaliine, massive limestone with dark-gray chert nodules.	800
Lower member. Dark-gray, finely crystalline limestone interbedded with calcareous siltstone, black shale, sandy limestone, and light-gray orthoquartzite.	1,600
middle thrust fault[b]	
Milligen Formation. Black to dark-gray argillite interbedded with light-gray lenticular beds of orthoquartzite.	1,850
lower thrust fault	
Devonian System	
Jefferson (?) Formation. Medium- to light-gray, finely crystalline, limestone interbedded with dolomitic limestone and bedded chert.	400

[a] Locally separates Pennsylvanian-Permian unit and Milligen Formation.

[b] Locally separates upper member White Knob Formation and Milligen Formation.

Igneous Rocks

Two small dikes, which are 1.5 to 3.0 feet wide, are situated a short distance uphill and north of the Tolman mine. They have been exposed by a bulldozer cut. The dikes are a few feet apart and are parallel. They apparently trend north-south and dip steeply, but are so badly weathered that exposures cannot be traced more than a few feet from the cut. Intrusion was into the White Knob Formation.

Two rock types are present in the dikes. The first has a porphyritic, subtrachytic texture. Phenocrysts are generally less than 0.5 mm in diameter. Calcite is abundant in this type as small veins and replaced phenocrysts. Relict pyroxene cleavage is frequently displayed by the calcite. Green secondary muscovite is also common. The orangish-tan iron oxide staining of the rock indicates that the muscovite is an alteration product of biotite. Some iron oxide is concentrated around small altered crystals of pyrite. Quartz is present as small anhedral crystals with undulatory extinction, suggesting stress conditions. It is often concentrated in small veins which are cut by calcite veins. Minor amounts of talc are also present. The second rock type has a porphyritic, subtrachytic texture with phenocrysts ranging from 0.25 to 3.0 mm. Secondary muscovite is present. Iron oxides are concentrated in small, dark reddish-brown euhedral masses which were once pyrite crystals. Quartz is present as microcrystalline replacement of phenocrysts. A few of these appear to be pseudomorphs after an amphibole. Some of the quartz phenocrysts are embayed and replaced by calcite. Some penninite is also present.

The original rock was probably a diabase which had pyroxenes, amphiboles and biotite. The first phase of alteration involved the introduction of silica. Quartz crystallized in small fractures and microcrystalline quartz replaced mafic minerals. Biotite probably altered to muscovite during the first phase. The second phase of alteration involved the introduction of calcite. Calcite is present as replacements of microcrystalline quartz which had formed during the first phase. Calcite also formed veins in new fractures and may have replaced remnant mafic minerals. Pyrite probably formed during the first two episodes of alteration. Alteration of pyrite to hematite and limonite is probably an effect of weathering. No dolomite or magnesite were detected by X-ray diffraction. Apparently the original rock was low in magnesium and may have had a composition more intermediate than basic.

Several lines of evidence indicate the existence of a stock beneath the southeastern part of the Black Pine Mountains. The concentration of mines and prospects there is one indicator. Contact metamorphism of the Milligen Formation in Black Pine Canyon is suggestive. Marblized limestone would also be supporting evidence if it has resulted from contact metamorphism instead of tectonic metamorphism.

Comparison with other near-by igneous rocks is hampered by the highly altered condition of the dike rock. It should be pointed out that intrusive rocks are found in the Raft River and Albion Ranges. Quartz monzonite is reported in the Raft River Range (Felix, 1956, p. 90). Quartz monzonite and granodiorite comprise the Almo pluton in the Albion Range (Armstrong and Hills, 1967,

p. 120). The nearest exposures of basic igneous rock are basalt flows about 20 miles south and southeast of the mapped area (Howes, 1972; Adams, 1962). Two ages of flow rock are present at the southern edge of the Snake River Plain to the northwest (Anderson, 1931). The difference in composition of the dikes and near-by plutons indicates that there is no genetic relationship between the dikes in the Black Pine Mountains and the postulated pluton beneath the study area.

STRUCTURE

General Statement

The Black Pine Mountains are situated near the northeastern corner of the Basin-and-Range province. Structure in this province generally demonstrates high-angle faulting superimposed on older folds and thrust faults. The Black Pine Mountains fit this pattern.

The complexity of the structure was recognized by Anderson (1931). He mapped the existence of several large folds, high-angle faults, and a thrust fault, which were truncated by a low-angle transverse fault. Concerning the overthrust, he reported that Mississippian beds, the Brazer Formation, had been placed over the younger Wells Formation. Recent investigations indicated the opposite relationship exists. The younger formations have been thrust over older ones.

Folds

In the southern part of the Black Pine Mountains, Anderson (1931) mapped several broad north-trending folds. He also reported the presence of an east-trending fold south of War Eagle Peak across the divide between Kelsaw and Black Pine Canyons. The existence of these folds could not be verified with certainty. Intense deformation of the strata impaired attempts to follow folded structures more than several hundred feet in most cases.

Some folds are mappable in the lower member of the White Knob Formation where it crops out in lower Black Pine Canyon. An anticline is located along the eastern side of the canyon below the fork. This structure roughly parallels the canyon and plunges north. It is truncated to the north by a high-angle thrust fault 0.5 mile south of the canyon fork. The anticline is nearly symmetrical. The limbs dip between 25 and 40 degrees. Width of the fold is about 0.25 mile. A syncline is adjacent on the west, and closely follows the canyon. The syncline is assymetric. The western flank has moderate east dips, 10 to 25 degrees, although several minor superimposed folds interrupt the continuity of the syncline. Magnitude of this fold is uncertain. It might be as wide as one mile. East of the anticlinal fold, the White Knob is masked by the upper thrust fault. However, west dips on the eastern side of the divide suggest that a syncline is present. The syncline is nearly symmetrical, with limbs which dip 30 to 40 degrees. The eastern limb is truncated by a range-front fault.

The Milligen Formation has absorbed much deformation in upper Black Pine Canyon. The interbedded quartzites of the formation have been more resistant and display an anticline bearing N. 20° W. This structure is traceable a short distance northward from near the canyon fork. It is symmetrical and the limbs dip about 35 degrees. This anticline has a width of about 0.75 mile.

As mentioned above, much of the White Knob dips west on the eastern flank of the divide. North of the Tolman mine, however, an overturned isoclinal anticline is present (Figure 7). The anticlinal axis strikes N. 10° W. and dips about 30° W. An overturned syncline adjoins it to the west. These folds are a few hundred feet wide. The folds are in the upper member of the White Knob Formation just below the upper thrust fault. A relationship to thrusting is implied.

Two recumbent overturned folds have been formed in the Pennsylvanian-Permian beds north of Mineral Gulch. An anticline and syncline are adjacent west to east. They trend N. 5° E. and are overturned to the east.

Low-Angle Thrust Faults

General statement

Three low-angle thrust faults are mapped in the southeastern part of the Black Pine Mountains. The faults are guided largely by bedding planes (Table 1). The lower thrust fault follows the Milligen-Jefferson (?) contact. The middle thrust fault is found at the White Knob-Milligen contact. Pennsylvanian-Permian rocks universally overlie the upper thrust fault, but may be in contact with White Knob or Milligen formations. Stratigraphic displacements are difficult to estimate because thrust faults intervene at inter-formational contacts; therefore, formation thicknesses are uncertain. Based on the figures given previously, stratigraphic displacements range from a few feet to over 2,000 feet. Horizontal displacements are unknown.

Lower thrust fault

This fault is exposed in a limited area in the center of Black Pine Canyon (Figure 8). The fault traces a sinuous pattern roughly following the contour for most of the distance around the canyon fork. The trace is truncated to the south by a landslide on the eastern canyon wall. Across the canyon it is sliced out by the middle thrust fault.

Gentle east dips on the thrust plane prevail where it is exposed on the eastern side of the canyon. On the western side, the fault assumes a west to northwest dip of variable steepness with a maximum of 25 degrees. There, the contact does not conform to the attitude of the Jefferson (?) Formation as it does elsewhere.

The lower thrust fault places the Milligen Formation above the limestones of the Jefferson (?) wherever it is seen. Evidence for its existence is the breccia zones in the Jefferson (?), which have been previously mentioned, and the discordant nature of the shale-limestone contact.

Middle thrust fault

The thrust fault which is found at the Milligen-White Knob contact is well displayed in Black Pine Canyon. It separates limestone from underlying shale on the southern side of War Eagle Peak (Figure 9) and on the slopes bounding the southwestern side of the canyon. The fault is cut off on the eastern and western sides of War Eagle Peak by normal faults. The exposure in the southwestern side of Black Pine Canyon disappears beneath the stream alluvium in the canyon. Another exposure of the thrust fault is below the cliffs near the Silver Hills mine. It is terminated in the saddle east of the mine by a normal fault. The thrust fault is present at the base of the cliffs north and west from the mine for about a mile before it is sliced out by the upper thrust fault. The middle thrust fault is covered along most of this trace but is well exposed in the Silver Hills mine portal.

On the eastern side of Black Pine Cone, near its base, the middle thrust fault, or branches from it, can be seen in the Tolman and Hazel Pine mines. Also, a shear zone has been encountered at shallow depth in drill holes in the vicinity of these properties (Richard Harris, 1974, per. comm.).

Wherever it is found, this fault places White Knob Formation over the Milligen Formation. In most places, stratigraphic succession has apparently not been interrupted. The important exception is above the Silver Hills mine where only the upper member of the White Knob is present. About 1,600 feet of the stratigraphic section has been cut out at that location.

Below the cliffs at the head of Black Pine Canyon, the fault dips north to northeast at angles ranging from 10 to 40 degrees. Drill holes and exposures indicate a dip of 10° W. on the eastern side of Black Pine Cone. The fact that the fault does not appear on the western side of Black Pine Cone, however, suggests that the middle thrust fault dips a minimum of 10° E. under the peak. Low-angle east dips are also mapped on the western side of lower Black Pine Canyon.

Upper thrust fault

The basal contact of the undifferentiated Pennsylvanian-Permian unit is a thrust fault in the studied area. Consequently, this is the most widely exposed thrust fault in the area. The plane of the upper thrust fault is irregular. It locally slices out the middle thrust fault and all of the White Knob Formation.

At the head of Black Pine Canyon, the upper thrust fault places undifferentiated Pennsylvanian-Permian rocks above the Milligen (Figure 9). The trace of the fault is terminated to the west by a normal fault east of War Eagle Peak. To the east, the fault crosses a saddle and follows a tributary into East Dry Canyon. There, the Pennsylvanian-Permian strata are placed above the upper member of the White Knob. The upper thrust fault ends against a normal fault in East Dry Canyon. In the area between War Eagle Peak and East Dry Canyon, the fault dips about 40° N.

The thrust fault underlies most of the north-south divide that separates Black Pine Canyon and Curlew Valley (Figure 8). The thrust plane there generally dips west at a low angle. On the canyon side of the divide, the fault has put undifferentiated Pennsylvanian-Permian beds above the Milligen in the upper part of the canyon. South of the canyon fork, beds of the lower White Knob Formation underlie the upper thrust fault. The fault is traceable around the southern end of the divide without change in stratigraphic juxtaposition.

On the valley side of the divide, the thrust plane displays variable attitudes making the trace discontinuous. A synclinal undulation of the plane drops the thrust fault outcrop beneath cover at the head of Burnt Basin. The southern limb of this synclinal feature has been eroded to expose the White Knob. These rocks dip 35° W., whereas slickenside surfaces on them dip 20° N. and show N. 88° W. as direction of movement.

On the eastern side of Black Pine Cone, the fault overlies the upper member of the White Knob. Its presence is dramatically displayed by a breccia locally containing large blocks of White Knob Limestone and Pennsylvanian-Permian sandstone (Figure 10). North of that site, the trace leads into the head of Mineral Gulch. There, the thrust plane assumes a north dip. The change causes the contact to follow the northern side of Mineral Gulch, bearing toward Curlew Valley. Near the mouth of the gulch, the trace crosses to the southern side and disappears under colluvium. Mining operations reveal shear zones which dip 25 to 45 degrees north at this locale.

A klippe of Pennsylvanian-Permian rocks caps the ridge on the southern side of Mineral Gulch. There, the thrust fault intervenes above the underlying White Knob Formation.

Stratigraphic deletion by the upper thrust fault ranges widely. On the eastern side of Black Pine Cone, the sequence is believed to be relatively complete. Over 2,700 feet of strata is missing southwest of the same peak where the fault overlies the Milligen.

High-Angle Thrust Faults

A high-angle thrust fault extends from Black Pine Canyon, a half-mile downstream from the canyon fork, to the head of Burnt Basin where it is terminated against a range-front fault. Near its western end, the fault is obscured by a landslide. On the western side of the canyon, the fault is lost in the lower member of the White Knob Formation. The strike is about N. 85° W. and the fault dips approximately 70°N. Displacement is minor, between 250 feet and 300 feet, and the northern side is up relative to the southern side. The trace of the upper thrust fault is offset by this fault but more important conditions are found near the base of the eastern wall of Black Pine Canyon. There, the lower member of the White Knob Formation has been faulted down against the Jefferson (?) Formation indicating over 1,800 feet of displacement. Apparently most of the intervening Milligen has been sliced out by low-angle thrust faults.

North-trending normal faults were mapped in Pole Canyon and Mill Fork Canyon adjoining the northern side of the study area (Anderson, 1931). These faults were truncated by the Kelsaw fault as mapped by Anderson (1931). Recent investigations indicate that at least one, the Pole Canyon fault, extends into Black Pine Canyon and is a high-angle thrust fault.

On the eastern side of War Eagle Peak, a high-angle thrust fault is found in the saddle separating Pole Canyon and Black Pine Canyon. The fault strikes N. 20° W. and dips 70° E. (Figure 9). It is lost in the Milligen Formation to the southeast. The eastern side is uplifted relative the western side, but the amount of displacement is made uncertain by the presence of thrust faults. Anderson (1931, p. 79) estimated 500 to 1,000 feet of displacement on the fault in Pole Canyon. The fault on the eastern side of War Eagle Peak is probably an extension of the Pole Canyon fault.

Normal Faults

Two parallel faults, bounding a small graben, bracket Black Pine Cone. These strike N. 84° W. but cannot be traced into the lower slopes around the peak. Displacement of the upper thrust fault indicates the southern fault has dropped the northern wall about 200 feet. The same block has been dropped 200 to 300 feet against the northern fault.

A fault, bearing N. 65° E., crosses a saddle on the northwestern side of War Eagle Peak. This trend takes the fault from the northern side of Kelsaw Canyon to a tributary of Pole Canyon, cutting the northwestern corner of the mapped area. The trace indicates a vertical attitude. The fault has dropped the undifferentiated Pennsylvanian-Permian strata against the upper member of the White Knob Formation. An estimate of displacement is impossible because of the presence of thrust faults.

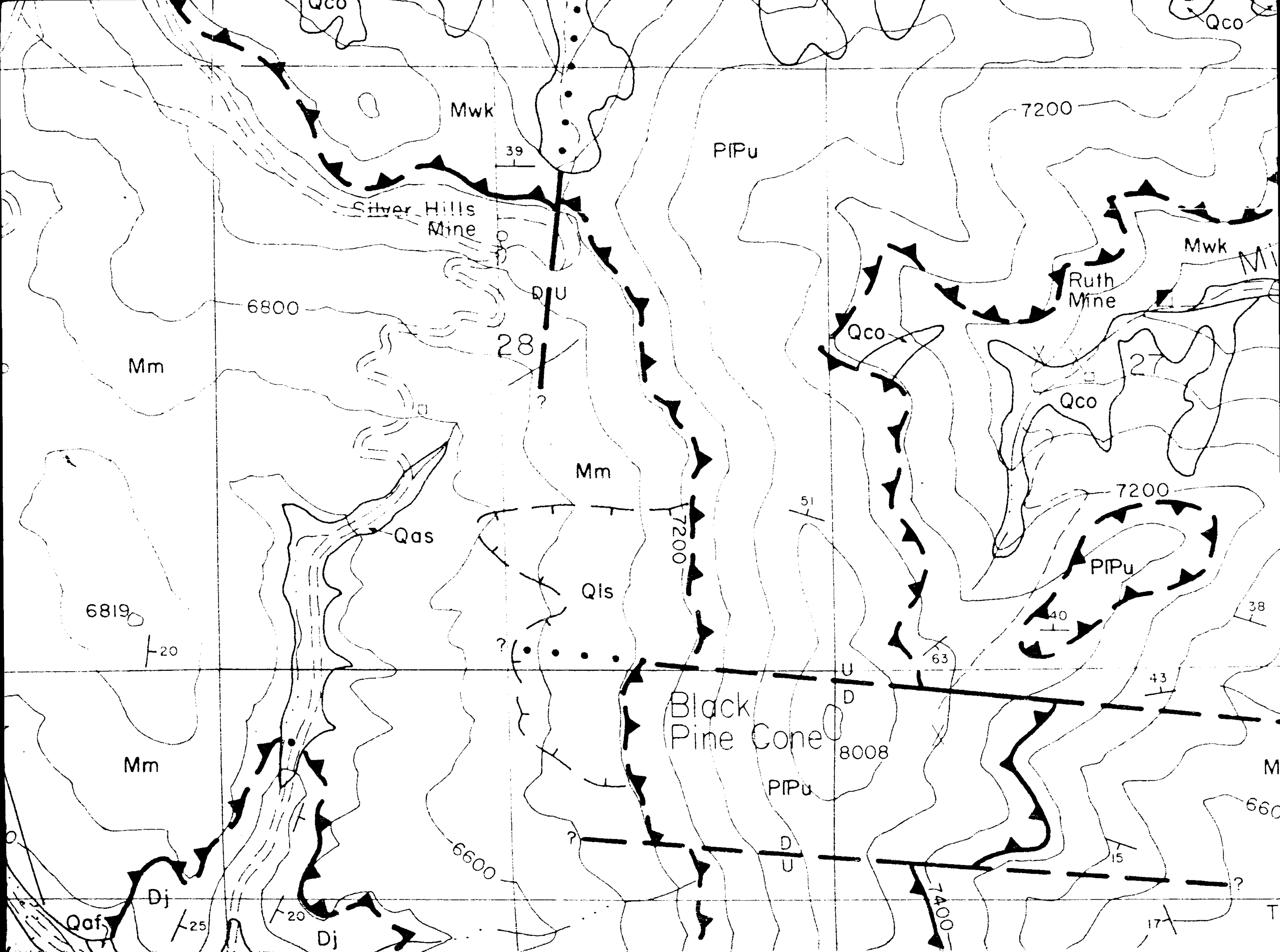
A north-trending normal fault is located 1.5 miles southeast of War Eagle Peak. It is situated in the saddle between Black Pine and East Dry canyons. It strikes N. 5° E. The fault disappears southward in the Milligen Formation. It is covered to the north in the head of East Dry Canyon. Movement was down to the east but determination of the amount of displacement is again complicated by thrust faults. The magnitude of movement is probably less than 1,000 feet. The fault has placed the undifferentiated Pennsylvanian-Permian unit on the eastern side, next to the upper member of the White Knob on the western side of the fault. The possibility exists that this is an extension of the fault that Anderson (1931) mapped at the head of Mill Fork Canyon.

Between the main mountain mass and the foothills on the southeastern flank of the range, a major range-front fault is located. This fault strikes N. 30° E. and is mapped as vertical. To the south, the fault extends beyond the studied area. Just north of the Hazel Pine mine it disappears beneath cover.

Movement was down to the east and dropped the Pennsylvanian-Permian strata in the foothills down against the lower member of the White Knob on the range flank. Displacement is uncertain but cannot be less than 4,500 feet and is more likely greater than 6,500 feet. Seismic surveys and drilling (Peace, 1956) indicate that this is one of several faults responsible for the relief of the eastern side of the Black Pine Mountains. A gravity survey located two other faults 1.0 and 0.5 mile east of the study area. Valley fill was estimated to be 6,000 feet thick by Cook, et al., (1964, p. 1725). This indicates that the total vertical displacement between the range and the Curlew Valley graben is about 15,000 feet or more. This assumes that the undifferentiated Pennsylvanian-Permian strata underlie the Tertiary and Quaternary valley fill. Drilling has verified this assumption (Peace, 1956, p. 28-30).

Landslides

Evidence of landslides is present in two small areas in Black Pine Canyon. They are situated on the eastern side of the canyon at the base of steep slopes of the undifferentiated Pennsylvanian-Permian unit. The areas are about a mile apart. One is located just below the canyon fork. The other is a short distance upstream from it. The northern landslide mass is resting on the Milligen Formation (Figure 8); whereas, the other overlaps the White Knob and Milligen. Neither area shows an alcove or scar. They are 2,000 to 3,000 feet across and debris is present as far as 2,000 feet downhill from the base of the steep slopes. The debris, found in the irregular terrain mapped as landslide deposit, is from the higher outcrops of calcareous sandstone and sandy limestone.



Qco
Mwk
39
PlPu
7200
Silver Hills
Mine
D U
6800
28
Mm
Ruth
Mine
Mwk
Qco
Qco
27
Mm
7200
Qas
7200
51
Qls
PlPu
6819
20
40
38
63
U
D
43
Black
Pine Cone
8008
PlPu
Mm
6600
D
U
15
Dj
Qaf
25
20
Dj
7400
17