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Description of Measured Sections of the Pennsylvanian Quadrant Sandstone, Beaverhead, Madison, and Park Counties, Southwestern Montana

by

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INTRODUCTION

This report contains stratigraphic descriptions and thickness measurements for the Pennsylvanian Quadrant Sandstone in portions of southwestern Montana and adjacent northwestern Wyoming (fig. 1). Field studies were conducted during the summers of 1983 and 1984. Although previous workers have described local aspects of the Quadrant Sandstone in southwestern Montana, few regional stratigraphic studies have been conducted (Gardner and others, 1946; Sloss and Mortiz, 1951; Maughan and Roberts, 1967). The objective of this report is provide detailed descriptions for the Quadrant Sandstone thereby extending present knowledge of Pennsylvanian stratigraphy in this part of the Rocky Mountain region.

Pennsylvanian strata in adjacent areas to the east (Bighorn Basin of Wyoming) and locally, areas to the south (Wyoming-Idaho Thrust Belt) have been proven to contain oil and gas-bearing sandstone reservoirs. In southwestern Montana however, attempts to produce oil and gas from wells that penetrated Pennsylvanian strata have been unsuccessful despite recent optimistic appraisals of hydrocarbon potential (Perry and others, 1983). To date, no drill cores were taken from these wells and therefore, little is known about potential reservoir rock such as the Quadrant Sandstone. Until the subsurface in this region, has been adequately sampled, the collection of stratigraphic information must rely chiefly on outcrop study.

In this report, ten stratigraphic sections are presented. For each section, descriptions of location, detailed lithologies and principal reference works are given. The type section for the Quadrant Sandstone, at Quadrant Mountain in Yellowstone Park, Wyoming, is also included for comparison with sections described in this study. This locality was not visited by the author.

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GEOLOGIC SETTING

In the study area shown in figure 1, the westernmost outcrops of the Pennsylvanian Quadrant Sandstone are distributed along the leading edge of the Montana Thrust Belt and eastern outcrops are located along the flanks of foreland uplifts farther to the east. Descriptions of the regional structural setting for this area have been given by Scholten (1967) and by Perry and others (1983).

The Quadrant Sandstone is southwestern Montana is the lithologic equivalent of the Tensleep Sandstone in Wyoming and regionally equivalent to parts of the Weber Sandstone and the Casper, Fountain, and Morgan Formations in Wyoming and Colorado (fig. 2). In eastern Montana and northeastern Wyoming, the Quadrant is correlative with the middle Member of the Minnelusa Formation. The Devils Pocket Formation underlies the Quadrant Sandstone in the Big Snowy Mountains of central Montana. In this area, the Devils Pocket is described as a sequence of mixed carbonate and sandstone strata that unconformably overlie the Amsden Group or Formation (Maughan and Roberts, 1967, p. 15). In southwestern Montana, equivalent units to the Devils Pocket of central Montana intertonge and grade into the sandstones of the overlying Quadrant Sandstone (Maughan and Roberts, 1967) (fig. 3).

In this report, the Quadrant Sandstone is defined to include a lower, dolostone member (Devils Pocket equivalent) that is conformably overlain by an upper, sandstone member (fig. 3). The dolostone member is differentiated by the first appearance of sandstone beds (greater than 1 m thick) interbedded with dolostone or minor amounts of siltstone that overlie either quartz-poor carbonate rocks and predominantly shaly beds of the Amsden Formation or older strata. The Quadrant Sandstone is overlain unconformably in most places by the Permain Park City Formation or by the Permian Shedhorn Sandstone. At places, the upper beds of the Quadrant may include strata as young as Early Permian (Maughan, 1975, p. 853). Faunal determinations have not been made and thus the age of the Quadrant Sandstone is considered here to be Desmoinesian in age based on the original biostratigraphic work of Thompson and Scott (1941) and Henbest (1954 and 1956).

The depositional setting of the Quadrant Sandstone is related to the regression of the Pennsylvanian Amsden Sea and the subsequent progradation of large amounts of quartz sand across the Wyoming Shelf in Wyoming and southern Montana. The overall succession of sandy carbonates (dolostone member) to quartz-arenties (sandstone member) is interpreted to represent a shallowing upwards marginal-marine to eolian depositional system. The observed thickening of the Pennsylvanian Quadrant Sandstone in southwestern Montana (fig. 3) suggest that differential subsidence and uplift across parts of the Wyoming Shelf were most active during the late Paleozoic and that these paleostructures greatly affected patterns of sedimentation during Quadrant deposition. Additional stratigraphic and paleotectonic interpretations for the Quadrant Sandstone are discussed in Saperstone and Ethridge (1984).

METHODS OF STUDY

All data presented here are from stratigraphic sections shown in figure 1. Field methods employed during the course of the study follow procedures outlined in Compton (1962). Most of the stratigraphic thicknesses were measured directly with 1.5 m (5 ft) Jacob staff and Brunton compass. At some locations in steeply dipping beds or topographically rugged areas, thicknesses were measured using a Brunton compass and tape. Thick intervals of talus-cover, which are common in parts of western Beaverhead County, have been estimated by compass and pace survey methods. Where accessible, dimensions of sedimentary structures such as cross-beds or horizontal bedding were measured directly with steel tape or ruler. Limits defined for bedding thickness follow the geometric grouping of Ingram (1954); very thickly bedded (>1 m); thickly bedded (30-100 cm); medium bedded (10-30 cm); very thinly bedded (1-3 cm); and laminated (<1 cm). Smaller scale features such as fossils, chert nodules, etc. were measured using a centimeter scale.

Geologic features of the stratigraphic sections which include lithology, color, texture, sedimentary structures, fossils, and in some instances topographic expression, have been described at the outcrop. Description of carbonate rocks follow the classifications of Dunham (1962) and Folk (1974) and are based on hand sample observation. The morphology of clastic cross-bedded units are classified using criteria outlined by McKee and Weir (1953) and by Harms and others (1982). Well-exposed surfaces on sandstone cross-beds were used to obtain dip directions of foreset beds. The maximum dips of foreset beds were obtained by measuring true dip only on those planar surfaces exposed in three dimensions at any outcrop. Inasmuch as sampling of cross-bedding measurements were determined by accessibility, no attempt was made to establish a uniform areal density of observation points. For those localities where regional structural tilting exceeded 5 degrees, the recorded cross-bed measurements were corrected by rotation about a horizontal axis.

Most of the stratigraphic sections of the Quadrant Sandstone in the Montana Thrust Belt and adjacent foreland (fig. 1) are exposed within structurally complicated terrains. At many places, the effects of tectonism or igneous activity have been to locally destroy or to modify primary sedimentary textures in such a way that a massive and vitreous appearance is imparted to the sandstone. These areas of tectonically altered sandstone commonly exhibit zones of intense shear and cataclasis, and create massive fracturing and jointing the produce extensive areas of talus cover. Where consistent structural dips could be obtained from isolated outcrops in talus-covered areas, a normal stratigraphic thickness was assumed. In relatively undeformed areas, poorly exposed intervals were judged to contain a dominant lithology based on the composition and texture of bedrock-derived colluvium, soil or float.

MIDDLE FORK LITTLE SHEEP CREEK (1A)
Gallagher Gulch 7 1/2' Quadrangle
NE 1/4 and N 1/2 sec. 34, T. 14S., R. 9 W.

Exposures of the Quadrant Sandstone are located in the valley of the Middle Fork of Little Sheep Creek (locality 1A, figs. 1 and 4) 13 km (8 mi) south of Lima approximately 460 m (1,500 ft) due south of the intersection of West Fork and Middle Fork roads. The basal contact of the Quadrant Sandstone with the underlying limestone beds of the Amsden Group (see Strickler, 1972, p. 89) can be located by proceeding southeast from Middle Fork to the East Fork campground access road where the initial point (point A, fig. 4) may be reached by walking a short ways to below the large sandstone spur approximately 61 m (200 ft) west of the line between sections 34 and 35 (point B). The traverse continues at point C (fig. 4) along the east-facing hillside near road level within the lower part of the Sandstone member. The traverse proceeds southwest to the timbered reentrant NE 1/4 of SW 1/4 of section 34 (point D) where the contact of the Quadrant Sandstone and the Permian Park City Formation is only poorly exposed due to faulting nearby. Additional geologic maps of the area are those by Scholten and others (1955) and Sadler (1981).

	Thickness	
	Meters	Feet
Park City Formation (Permian):		
Grandeur Member [incomplete]:		
7. Poorly exposed, mostly sandstone; slightly calcareous; medium-grained, well-sorted, well-rounded; friable, slightly argillaceous; contains some low-angle tabular-planar and high-angle cross-beds; interbedded with cherty dolostone.....	9.1+	30.0+
6. Dolostone and chert, partly concealed; similar in lithology to unit 5 below; very thin bedded and algal laminated; weathers to very ligh-gray colored ledge. Estimated thickness.....	15.2	50.0
5. Dolostone, light-brownish-gray, slighly silty, chert lenses as much as 2 ft (0.6 m) long; medium to thin bedded; base of unit is sandy. Conodont sample locality 29748-PC....	2.3	7.5
4. Poorly exposed, mostly sandstone, seems argillaceous; medium grained, well sorted; tabular-planar cross-beds observed in sandstone blocks in float; possibly some dolomitic sandstone interbeds. Estimated thickness.....	15.2	50.0

	Thickness	
	Meters	Feet
3. Sandstone, dolomitic; pale yellowish orange to white; medium-grained and moderately sorted; slightly argillaceous; upper part of unit is slightly coarser and less carbonate cemented than the lower part; top of unit contains thin sandy dolostone interbeds; unit contains abundant ripple laminae and areas of vuggy weathering.....	6.1	20.0
2. Sandstone, dolomitic; very pale orange; well indurated; medium-bedded; shows evidence of shearing and small-scale folding.....	1.2	4.0
1. Covered, possible fault zone; abundant slickensided surfaces on closely spaced jointed sandstone blocks; lithology in float similar to unit 38 below; colluvium contains chert and dolomicrite fragments; soil color is very pale orange.....	Not measured	
Total measured part of Grandeur Member.....	49.1	161.5+

Quadrant Sandstone (Pennsylvanian):

Sandstone Member:

39. Poorly exposed, sandstone; very pale-orange to very light-gray; only locally calcareous; predominantly medium- to fine-grained; variably indurated: friable to silica cemented in the vicinity of intensely fractured areas; lower part weathers to nodular masses about 5 to 15 cm (2 to 6 in.) in diameter within thin-bedded horizontally laminated intervals; locally sandstone is mostly medium to fine grained containing very large sets of tabular-planar high-angle cross-beds with set height about 3 m; much loose sand and slickensided sandstone fragments in float. Estimated thickness.....	143.6	471.0
38. Sandstone, calcareous; fine- to medium-grained, well-sorted, well-rounded; horizontally bedded to low angle cross-bedded; bioturbated in part.....	1.5	5.0
37. Sandstone, light-gray to very light-gray, calcareous in part; low angle cross-bedded to horizontally laminated; some bioturbated intervals; thin to medium-bedded, conspicuous cannonball-sized sandstone concretions weather from outcrop.....	6.7	22.0

		Thickness	
		Meters	Feet
36.	Sandstone, same lithology as unit 34 except characterized by low-angle bidirectional cross-laminae; not as poorly bedded as units below; overlain by high-angle tabular-planar cross-beds, set height approximately 1.5 m (4.9 ft).....	2.5	8.2
35.	Sandstone, light gray to very light gray; medium-grained, well-sorted, subangular to rounded; poorly bedded, bioturbated, mottling occurs as circular blebs ranging in size as much as 4 cm (1.5 in.) in diameter; fine- to granule-size quartz sand occur as grain lag surfaces along disrupted foreset laminae; some rare fracture-filled sandstone dikes.....	3.0	10.0
34.	Sandstone, base of unit contains zone of intense fracturing, finely granulated in plane of major fault zone exposed along gulch wall, locally sandstone has undergone cataclastic deformation; slickensides on upper block; lower block contains sandstone breccia and extensive fracture cleavage; thickness of shear zone unknown. Top of unit is poorly exposed, mostly isolated outcrops of sandstone containing some wedge-planar cross-beds overlain by high-angle tabular-planar cross-stratification with set heights as much as 60 cm (1.9 ft). Approximate total unit thickness.....	52.1	171.0
33.	Poorly exposed, mostly sandstone, very pale-orange to light-gray with carbonate-cemented interbeds; friable in part; isolated outcrops show cross-stratification ranging from high-angle tabular-planar beds with set height > 2 m (6.6 ft) to wedge-planar sets with set heights of 10 to 20 cm (3.9 to 7.8 in.). Cross-beds have an average dip direction of S. 20 E. Interval is mostly sandstone colluvium and talus along hillslope. Estimated thickness.....	88.4	290.0
32.	Dolostone, sandy; very pale-orange to very pale-pink; similar to exposures of sandy dolostone in unit 29 below.....	0.5	1.5
31.	Sandstone, very pale-orange, weathers dark gray; mostly indistinct bedding; some cross-laminae at top of unit.....	0.6	2.0

		Thickness	
		Meters	Feet
30.	Dolostone breccia, weathers dark gray; sandstone clasts in carbonate matrix; highly weathered, vuggy to fenestral in texture.....	0.1	0.3
29.	Poorly exposed, dolomitic sandstone; very fine-grained; weathers light gray; well indurated.....	1.5	5.0
28.	Covered, float contains varicolored sandstone chips and fragments some of which are marked by liesegang bands; some sandstone in float contain slickensided surfaces; extremely friable. Estimated thickness.....	25.6	84.0
27.	Sandstone, poorly exposed; lower part is light grayish orange; bioturbated at base; overlain by tabular-planar cross-bedding with set heights greater than 1 m (3.3 ft); cross-beds have an average dip direction of S. 87 E.....	1.2	4.0
26.	Sandstone, mostly wedge-planar cross-laminated with set heights about 30 cm (1 ft) with lesser amounts of medium scale cross-bed sets with heights of 70 cm (2.3 ft) or less; occasional wedge-planar and trough sets with concave-up bottomset contacts; upper part of unit is pale yellowish orange to distinctive dark-yellowish orange weathering sandstone; some high-angle cross-beds overlie cross-bedding with strongly tangential basal contact, cross-beds have an average dip direction of S. 02 W.; some liesegang bands on sandstone fragments and slickensided surfaces on sandstone chips in float. Exposures limited to isolated outcrops along talus-covered slopes. Estimated thickness.....	41.1	135.0
25.	Sandstone, fine- to medium-grained, well-sorted, well-rounded; ripple-laminated to irregularly horizontally laminated; in places there are anastomosing networks of gouge-filled microfractures some of which are several cm wide.....	4.5	14.7
24.	Dolostone, sandy and light-gray dolomicrite, weathers very pale orange to white; medium bedded. Conodont sample locality 29747-PC.....	0.6	2.0
23.	Dolomitic limestone, yellowish-gray; sandy at base; very thin bedded and finely laminated; contains nodules of dolomite less than 1 cm (0.4 in.) in diameter; slightly fetid odor on fresh surface. Conodont sample locality 29746-PC.....	0.6	2.0

		Thickness	
		Meters	Feet
22.	Dolostone breccia with dolomitic sandstone clasts ranging in size as much as 8 cm (3.1 in.); matrix is dominantly fine-grained sandstone; disconformably overlain by calcareous dolostone; this contact is marked by brownish-orange highly weathered mudstone.....	0.2	0.5
21.	Sandstone, medium- to fine-grained; low-angle, medium-scale, tabular-planar cross-stratification, set height approximately 0.4 m (1.3 ft); overlain by horizontally laminated carbonate-cemented sandstone.....	2.5	8.2
20.	Poorly exposed, sandstone, very pale-orange to light-gray; well-sorted, rounded; rare sandstone blocks in colluvium show convolute bedding and liesegang bands; locally, sandstone fragments are extremely siliceous and iron oxide stained. Estimated thickness.....	30.5	100.0
	Traverse offset from point C to East Fork-Little Sheep Creek at point B		
19.	Sandstone, very pale-orange to light-gray; medium- to fine-grained, well-sorted, subrounded to rounded; mostly high-angle large-scale tabular-planar cross-bedded with set heights that average 1 to 3 m (3.3 to 9.8 ft) but may be as thick as 10 m (33 ft); common horizontal laminae with thin tabular-planar cross-laminated sets containing tangential lower bounding surface contacts; some wedge-planar low-angle medium-scale cross stratification with set heights about 50 cm (1.6 ft); cross-beds have an average dip direction of S. 28 W.; outcrop forms resistant divide between Middle and East Forks of Little Sheep Creek. Estimated thickness.....	44.2	144.9
18.	Sandstone, carbonate-cemented; very light-gray; areas of dolomite replacement; some iron oxide staining; mostly irregular laminae and massive bedding; possibly bioturbated; ripple bedded to small-scale cross-stratified in middle of unit; top of unit is horizontally laminated.....	0.5	1.7

	Thickness	
	Meters	Feet
17. Sandstone, very light-gray to white, weathers light gray; medium- to fine-grained, well-sorted, rounded; large-scale cross-bedding locally contains tabular-planar cross-laminated subunits with set heights 1 to 2 m (3.3 to 6.6 ft) in size; some smaller wedge-planar sets with set heights about about 4-5 cm (1.8 in.); locally, foreset laminae form tangential contacts with the lower bounding surface; cross-beds have an average dip direction of S. 18 W.; outcrop forms series of cross-bedded sandstone ledges below sandstone prominentory.....	5.1	16.8
16. Sandstone, calcareous; pale-yellowish-orange; medium- to fine-grained, well-sorted, subangular to subrounded; friable; textural maturity increases upward; iron oxide staining at base. Forms small ledge.....	3.2	10.5
Total Sandstone member.....	460.3	1510.3
Dolostone member:		
15. Dolostone, and dolomicrite; calcareous in part; light gray; well-indurated; fetid odor on fresh surface; sharp contact with overlying unit. Conodont sample locality 29745-PC.....	1.4	4.5
14. Dolostone, very pale-orange to pale-yellowish-orange; some sparry calcite and rare dolomite mottling, both features less than about 2 cm (3/4 in.) in diameter; finely laminated in part; fetid odor on fresh furface; thin-bedded bioclastic limestone at top.....	0.4	1.3
13. Covered.....	1.2	4.0
12. Sandstone, same lithology as unit below; top 0.5 mi (1.6 ft) is horizontally-laminated and contains thin prominent bedding plane ironstone partings and iron oxide mottling as well as selective staining along laminae; irregular areas of dolomite replacement along some bedding boundaries.....	0.6	2.0
11. Sandstone, light-gray to buff; fine-grained, well-sorted, subrounded to rounded; mostly tabular-planar to wedge-planar cross-beds, set height approximately 1 m (3.3 ft). Cross-beds have an average dip direction of S. 29 W.....	2.8	9.2

		Thickness	
		Meters	Feet
10.	Sandstone, dolomitic, very pale-orange; very fine-grained, rounded; well-indurated; grades upward into moderate yellowish-orange sandstone, friable; contains conspicuous iron oxide staining throughout; thin-bedded; mostly horizontally laminated with some irregular laminae; some medium-scale trough cross-beds with set height about 15 cm (5.9 in.).....	0.2	0.5
9.	Poorly exposed, probably sandstone and dolostone; forms swale at bottom part of unit; part of upper unit probably similar to unit 10 above.....	5.2	17.2
8.	Dolomitic limestone, very pale-orange to pale-yellowish-orange gray; contains crinoid and brachiopod bioclasts; extremely fetid odor on fresh surface; thin- to thickly-bedded; hackly fracture. Conodont sample locality 29744-PC.....	1.8	6.0
7.	Zone of intense fracturing and shearing; poorly exposed; mostly sandstone and buff-colored fine-grained dolomitic sandstone; abundant sandstone fragments in float have slickensided surfaces.....	2.4	8.0
6.	Sandstone, very pale-orange; medium-grained, well-sorted, rounded; thin- to thick-bedded; friable; some iron oxide halos 0.5 cm (0.2 in.) wide; common low-and high-angle cross-bedding with set heights about 50 cm (19.5 in.) cross-beds have an average dip direction os S. 25 W.; some irregular bounding surfaces near top of unit; spheroidal weathering at some places.....	10.4	34.2
5.	Sandstone, very light gray to white, weathers light gray; medium-grained, well-sorted, rounded; friable; some low-angle tabular-planar cross-stratification, set height about 1 to 2 m (3.3 to 6.6 ft). Cross-beds have an average dip direction of S. 11 W.....	6.9	22.5
4.	Dolostone, silty to very fine-grained; quartzose; coarsely crystalline with interbedded pale-yellowish gray sandstone; poorly exposed. Estimated thickness.....	9.9	32.5
3.	Sandstone, calcareous; pale-yellowish-orange with interlayered dolomitic sandstone;fine-grained, well-sorted, subangular; poorly exposed in hillslope colluvium.....	2.6	8.6

	Thickness	
	Meters	Feet
2. Sandstone, buff to very pale-orange, weathers light gray; medium-grained to fine-grained, very well-sorted, subrounded to rounded; possibly thick-bedded; variably silica and calcite cemented; conspicuous sandstone concretions in float measuring 3 to 10 cm (1.2 to 3.9 in.) in diameter.....	7.2	23.7
1. Poorly exposed, probably dolomitic sandstone and siltstone; weathers light gray to grayish orange; top of interval is more quartzose and well indurated; dense dolostone occurs in float. Estimated thickness.....	5.5	18.0
Total Dolostone member.....	58.6	192.2
Total Quadrant Sandstone.....	518.9	1702.5
Amsden Group (Pennsylvanian):		
Alaska Bench Limestone [incomplete]:		
6. Limestone and sandy dolostone, light grayish orange; approximately 10 percent quartz; bioclastic in part; some birdseye fenestrae; top of unit is more dolomitic and carbonaceous; weathers very pale brownish gray. Conodont sample locality 29743-PC.....	1.5	5.0
5. Dolostone, medium yellowish gray; coarsely crystalline; medium-bedded; base partly concealed. Conodont sample locality 29742-PC...	1.8	6.0
4. Limestone poorly exposed; medium light gray; slightly bioclastic (wackestone); some sparry calcite. Conodont sample locality 29741-PC.....	2.6	8.5
3. Dolostone, light grayish orange; coarsely crystalline; medium-bedded; limestone and chert breccia at base of unit.....	0.9	3.0
2. Chert and dolostone, medium light gray to pale-yellowish brown; sharp contact with unit above.....	1.0	3.2
1. Siltstone and sandstone, calcareous and interbedded with silty limestone; very pale orange; rare bioclasts; thin-bedded; top partly concealed. Conodont sample locality 29740-PC.....	3.0	10.0
Total measured part of Alaska Bench Limestone.....	10.8+	35.7+

WEST FORK LITTLE SHEEP CREEK (1B)
Gallagher Gulch 7 1/2 ' Quadrangle
SW 1/4 sec. 27 and NE 1/4 sec. 33, T. 14 S., R. 9 W.

The section at West Fork of Little Sheep Creek (locality 1B, figs. 1 and 4) is located just west of the Middle Fork section (1A). The initial point of the traverse (point E) is located approximately 0.8 km (0.5 mi) west of the intersection of the West Fork and Middle Fork of Little Sheep Creek (see also Strickler, 1972, p. 88, section 11). The Quadrant-Amsden contact is located just above road level on the northwest side of the road. Proceed southwest 1.22 km (0.75 mi) to Gallagher Gulch where a short side traverse reveals exceptionally well-developed Quadrant Sandstone cross-beds. These outcrops may be easily reached by hiking 152 m (500 ft) due north from the confluence of West Fork and Gallagher Gulch. The contact between the Quadrant and the overlying Park City Formation (point F) is only moderately exposed just beyond Gallagher Gulch in the Center of Section 33.

	Thickness	
	Meters	Feet
Park City Formation (Permian):		
Grandeur Member [incomplete]:		
5. Poorly exposed, dolostone and limestone in float.....	Not measured	
4. Poorly exposed, sandstone similar to Quadrant Sandstone unit 9; forms covered slope. Estimated thickness.....	4.9	16.0
3. Siltstone, yellowish-gray; thin-bedded to finely laminated; bioturbated, mudcracked, contains circular-shaped calcareous nodules about 6 cm (2.3 in.) in diameter; some thin cherty laminae.....	9.1	30.0
2. Dolostone and thin interbedded dolomitic sandstone; lower part of unit contains chert lenses measuring 2 by 10 cm (0.8 by 3.9 in.) by in size. Conodont sample locality 29749-PC.....	6.1	20.0
1. Dolostone, sandy, and dolomicrite; sandy dolostone is very pale orange to yellowish gray and has a gradational contact with yellowish-gray dolomicrite subunit above; unit also has thin sandy interbeds containing approximately 1 to 5 percent heavy minerals in the sandier layers.....	3.0	10.0
Total measured part of Grandeur Member.....	23.1+	76.0+

	Thickness	
	Meters	Feet
Quadrant Sandstone (Pennsylvanian):		
Sandstone member:		
9. Sandstone, very pale-orange, medium- to coarse-grained, well-rounded; slightly argillaceous; contains sets of segregated medium- and coarse-grained laminae in alternating layers about 1 to 5 cm (0.4 to 2 in.) thick; upper part of unit poorly exposed, probably sandstone with segregated laminae of subunit below; upper part of outcrop contains low-angle tabular-planar and wedge-planar cross-stratification; cross-beds have an average dip direction of S. 11 W.; top of unit contains fine-to coarse-grained, and locally bimodal to moderately sorted, well-rounded sandstone. Estimated thickness.....	117.3	385.0
8. Sandstone, very pale orange, medium- and fine-grained, well sorted, well rounded; some iron oxide staining; distinctive large-scale tabular-planar and wedge-planar corss laminae, set height equal to or greater than 1 m (3.3 ft); cross-beds have an average dip direction of S. 49 W.; medium-to thin-bedded; forms talus-covered slope an cliffs Estimated thickness.....	123.7	405.9
7. Sandstone, poorly exposed, pale-yellowish-orange, to light-gray, may be stained light-brownish-red; mostly fine- to medium-grained, well sorted and rounded; locally may be intensely fractured and faulted with abundant slickensided surfaces among sandstone fragments in float and on isolated outcrops. Estimated thickness.....	63.2	207.4
6. Covered, probably similar to unit 7 above. Estimated thickness.....	210.4	690.3
5. Covered, similar to unit 7. Estimated thickness.....	56.4	185.1
4. Sandstone, dark-yellow and pale-yellowish-orange; fine-grained; contains horizontal to low-angle and wedge-planar cross-laminae, set height approximately 1 m (3.3 ft); some large-scale convolute bedding present in large sandstone slabs in float; poorly exposed. Estimated thickness.....	37.1	121.7
Total Sandstone member.....	608.4	199.4

	Thickness	
	Meters	Feet
Dolostone member:		
3. Poorly exposed, mostly dolostone and dolomitic sandstone; becomes more quartzose toward top of unit; float is mostly pale yellowish orange sandstone near top of unit; locally, zones of possible faulting. Estimated thickness.....	38.3	125.8
2. Dolostone, very pale-orange; thinly laminated; some boxwork textured weathering; overlain by subunits of dolostone and sandy dolostone, weathers to pale yellowish orange and dark yellowish orange; well indurated, coarsely crystalline in part; thin bedded; pink regolith at top of unit. Forms thin ridge.....	4.5	14.6
1. Limestone and dolomitic sandstone, weathers pale yellowish orange; some lesser amounts of interbedded calcareous siltstone.....	3.4	11.1
Total Dolostone member.....	46.2	151.5
Total Quadrant Sandstone.....	654.3	2146.9
Amdsen Group (Pennsylvanian):		
Alaska Bench Limestone [incomplete]:		
1. Poorly exposed, probably limestone (wackestone), medium dark gray, pelloidal and intraclastic.....	0.6+	2.0+
Total measured part of Alaska Bench Limestone.....	0.6+	2.0+

BIG SHEEP CREEK-HIDDEN PASTURE TRAIL COMPOSITE SECTION (2)
Dixon Mountain 7 1/2 ' Quadrangle
SE 1/4 sec. 35 and NW 1/4 sec. 36 T.13 S., R.10W.

The Hidden Pasture-Big Sheep Creek section (locality 2, figures 1 and 5), was described along three separate traverses at: (1) Hidden Pasture Trail; (2) Big Sheep Creek Canyon, and; (3) along an unamed gulch adjacent to Big Sheep Creek located one drainage south of Hidden Pasture Trail (figure 5). At Hidden Pasture Trail, the Quadrant Sandstone is underlain by limestones of the Amdsen Group and older rocks which form a normal succession of late Paleozoic rocks on the hanging wall of the Tendoy Thrust.

The section is reached by taking Big Sheep Creek road for approximately 11.3 km (7 mi) west from Dell, Montana. The turnoff to Hidden Pasture Trail is marked by a Forest Service sign. Proceed on foot northwesterly on Hidden Pasture Trail for about 180 m (600 ft) where gray limestone of the Amsden Group is visible on the east side of the valley (point A, fig. 5). Outcrops are continuous to the top of the first resistant tree-covered ridge. Beyond this point (point B) all slopes are talus-covered.

This section traverse is offset across Hidden Pasture Creek to the northwest side of Big Sheep Creek Canyon (point C, figure 5). Proceed about 60 m (200 ft) above the road level and continue westward through the middle and upper parts of the Sandstone member. The uppermost units of the Quadrant and overlying Phosphoria rocks are best exposed along the scoured bedrock surfaces found along a steep unamed tributary to Big Sheep Creek in NW 1/4 of SE 1/4 section 35 (points D, and E, figure 5). Additional references to Pennsylvanian rocks at this locality are those by Dillon (1947, p. 24-25), Sloss and Moritz, (1951, p. 2165), Strickler, (1972, p. 85, section no. 1), and Klecker (1981, p. 33-39).

Phosphoria and Park City Formations undivided (Permian) [incomplete]:

		Thickness	
		Meters	Feet
9.	Bedded chert, very light-gray, and dolostone; hackly fracture; contains large bluish-gray chert nodules as much as 15 cm (5.9 in.) in diameter; forms series of resistant benches; becomes more dolomitic toward top.....	15.6	51.3
8.	Mostly covered; some isolated outcrops of sandstone, thin-bedded, flat-laminated to cross-laminated; weathers to slabby ledges and blocks.....	94.2	309.0
7.	Siltstone, calcareous; organic-rich; medium dark-gray; weathers yellowish gray; prominent calcite nodules up to 6 cm (2.3 in.) in diameter; very thin bedded and forms a series of flaggy weathering ledges.....	4.3	14.0
6.	Sandstone, dolomitic, very light-gray, weathers light yellowish gray, well indurated, thin bedded with occasional irregular laminae; poorly exposed along creek bottom.....	6.4	21.0

	Thickness Meters	Thickness Feet
5. Partly covered, some calcareous sandstone (base only); very fine-grained; horizontally laminated in part; mostly thin to massive bedded; upper part of unit is only poorly exposed along creek bottom.....	22.6	74.0
4. Dolostone, sandy; very pale-orange to light-gray; well-indurated and coarsely crystalline dolostone with sandy interbeds that show a slight fining-upwards in grain size within the upper 2/3 of the unit; laminated to very thin bedded; some low-angle bidirectional cross-bedding within the sandier intervals.....	13.6	44.5
3. Dolostone and dolomitic sandstone, light-yellowish-gray, medium- to thick-bedded with conspicuous chert and dolomite mottling; some iron oxide staining along laminae traces; sharp contact with overlying sandy dolostone.....	1.1	3.5
2. Dolomicrite, silty; very pale-orange; some iron oxide stained laminae; medium-bedded; some intercalated very thin dolomitic siltstone. Conodont sample locality 29738-PC.....	2.4	8.0
1. Sandstone, and sandy dolostone, calcareous, very light-gray containing very coarse- to granular-chert grains; some chert nodules at the base.....	0.2	0.8
Total measured part of Phosphoria and Park City Formations...	160.4	526.1+

Quadrant Sandstone (Pennsylvanian):

Sandstone member:

61. Sandstone, carbonate-cemented, very pale-orange, weathers medium light gray; very fine-grained, thick-bedded; locally contains irregular patches of dolomite. Upper part contains distinctive chert nodules as much as 8 cm (3.1 in.) in diameter. Sharp contact with interlayered dolostone is marked by a zone of deeply weathered sand that is light olive brown to moderate yellow, very fine to medium grained and moderately sorted.....	3.0	10.0
60. Sandstone, carbonate-cemented, sandy, very light-gray, weathers yellowish gray; silty to medium-grained, moderately well-sorted; well-indurated; medium- to thick-bedded and contains laminae of quartz and disseminated medium- to coarse-grained chert grains and 0.1 to 0.2 mm sized sparsely disseminated pyrite.....	0.2	0.8

		Thickness	
		Meters	Feet
59.	Sandstone, dolomitic (50%-75% quartz) and calcareous sandstone; light-gray, weathers medium gray; medium- to fine-grained; well-indurated; well-sorted, subangular to rounded; some iron oxide staining; thin-bedded; becomes more dolomitic upward in section. Top is pale yellowish orange, carbonate cemented sandstone that weathers very light gray; contains some sparry calcite and iron oxide mottling.....	2.7	9.0
58.	Sandstone, calcareous in part, irregular zones of dolomitic sandstone, very pale orange, fine-to medium-grained; fine horizontal laminae to massive bedded; abundant fractures and sandstone breccia due to intense deformation throughout lower portion of unit; becomes more dolomitic near top.....	9.8	32.0
57.	Sandstone, locally may be calcareous, very pale orange, weathers light gray; medium- to fine-grained; well-sorted, subrounded, well-indurated; some iron oxide halos as much as several mm (about 1/8 in.) in diameter. Lower part is very thin planar bedded to laminated with alternating sets of medium-grained and fine-grained sandstone laminae, capped by low-angle tabular-planar cross-beds whose foreset toes show normal grading; numerous fractures oriented at hight angles to bedding. Upper part of unit is very thick bedded and very fine grained sandstone with occasional large-scale tabular-planar low angle cross-beds containing decreasing set height from 4 to 0.1 m (13.1 ft to 3.9 in.); cross-beds have an average dip direction of S. 52 W.; some iron staining is prominent as liesegang bands. Outcrop restricted to exposures along bedrock-scoured creek bed.....	24.1	79.0

Traverse continues at point D northwest to point E (fig. 5)

56.	Sandstone, very pale-orange; fine-grained, well-sorted; subrounded to rounded; well-indurated; mostly tabular-planar cross-laminated and very thin-bedded; forms discontinuous cliffy ledges and areas of talus cover.....	9.1	30.0
55.	Covered, interval forms steep talus covered slopes. Estimated thickness.....	180.4	592.0

		Thickness	
		Meters	Feet
54.	Sandstone (lower part) calcareous, very pale orange, very fine-grained to medium-grained, poorly sorted, subrounded, well-indurated; ripple laminated; lower subunit overlain by medium-grained, well-sorted subrounded to rounded friable sandstone with horizontal to low-angle wedge-planar laminae with set height about 1 m (3.3 ft). This upper sequence comprises a 0.5 m (1.6 ft) thick interval; cross-beds have an average dip direction of S. 10 W. Uppermost part of unit is covered.....	11.6	38.0
53.	Covered, interval forms steep talus covered slopes. Estimated thickness.....	22.9	75.0
52.	Sandstone, pale-yellowish-orange, fine-grained, well-sorted, subrounded; some iron oxide staining throughout. Mostly large-scale high-angle tabular-planar and wedge-planar cross-bedding, set height as much as 10 m (33 ft); cross-beds have an average dip direction of S. 05 W.; intercalated horizontal bedding with segregated laminae containing fine-grained and medium grained sandstone in couplet sets about 5 cm (2 in.) thick. Forms series of cliffs.....	12.5	41.0
51.	Sandstone, calcareous at base, pale-yellowish-orange, medium- to fine-grained, moderately well-sorted, subrounded, partly-indurated; some iron oxide staining; very thin-bedded at base becomes medium-bedded and more indurated toward top; low-angle tabular-planar and horizontally laminated throughout. Top of unit shows small-scale trough and low-angle wedge-planar cross-bedding, set height approximately 15 cm (5.9 in.); occasional spheroidal weathering characterized by nodular masses about 3-5 cm ($1\frac{1}{2}$ in.) in diameter.....	6.1	20.0
50.	Sandstone, buff to very pale-orange, weathers light gray, medium-grained, mostly well-sorted, subrounded to rounded, friable in part, some low-angle tabular-planar cross-bedding, set height approximately 1 m (3.3 ft) or less; cross-beds have an average dip direction of S. 39 W.....	35.7	117.0

		Thickness	
		Meters	Feet
49.	Sandstone, (base only), white to very light-gray, fine-grained, well-sorted, subrounded, friable; abundant iron oxide halos as much as several mm (about 1/16th in.) in diameter; mostly large-scale planar cross-bedding and planar horizontal laminae; some medium-scale wedge-planar cross-bedding, set height ranges from 1.5 m (5 ft) to (6.6 ft) 2.0 m. Top 20 m (66 ft) of unit is poorly exposed; highly fractured outcrops weathers to massive blocks as much as 10 m (33 ft) in size with occasional slickensided surfaces. In places, there are botryoidal-shaped ironstone partings about 1 to 5 mm (1/16 to 1/4 in.) in thickness.....	19.8	65.0
48.	Sandstone, light-gray, fine-grained, well-sorted, well rounded, well indurated; medium- to very thick-bedded and horizontally laminated; a few partings of ironstone similar to those in the overlying unit occurring parallel and at high angles to bedding. Sandstone outcrop forms steep cliff.....	7.0	23.0
47.	Sandstone; lower part, buff to very pale-orange and light-gray; fine-grained, well-sorted, to rounded, variably indurated, fractured throughout, some slickensided surfaces; upper part weathers light pink; well indurated, horizontally laminated showing well-defined segregation laminae and parting lineation along bedding planes; very thick to massive bedded at top.....	10.1	33.0
46.	Fault zone; extremely siliceous; granulated sandstone and sandstone breccia; prominent color alteration in shear zone. Abundant slickensided surfaces.....	3.0	10.0
45.	Sandstone very pale-orange to light-gray; medium- to coarse-grained at base, grading upward to fine-grained at top; sorting and rounding improves upward; locally contains thin intervals (cm's) of medium-grained horizontal laminae; moderately well sorted, subrounded. Base of unit is irregularly-laminated calcareous siltstone that is variably calcite and silica cemented; thin weathered zones appear vuggy and friable; mostly horizontally laminated throughout and some ripple-laminations with indistinct irregular laminae. Top 9 m (30 ft) mostly low-and high-angle tabular-planar cross-laminae with light pink to yellowish orange staining. Forms steep slopes and ledges.....	15.2	50.0

		Thickness	
		Meters	Feet
44.	Sandstone, calcareous, very light-gray to pale-yellowish-orange, fine-grained; coarsens upward slightly to medium-grained; horizontally bedded and low- to high-angle tabular-planar cross-stratification as much as 1 m (3.3 ft) or more in set height. Cross-beds have an average dip direction of N. 85 E.....	9.1	30.0
43.	Covered, except for small areas of poorly exposed sandstone; quartzose, pale-yellowish-orange to light-gray; medium- to fine-grained; cross-bedded. Estimated thickness.....	42.1	138.0
42.	Sandstone, pale-yellowish-orange, medium- to fine-grained, well-sorted, subrounded; contains large-scale low-angle trough cross-bedding and very thin horizontal beds. Outcrops poorly exposed.....	9.8	32.0
41.	Sandstone, pale-yellowish-orange to pale-grayish-orange; siliceous, medium-grained, well-sorted, subrounded; well-indurated; some ripple laminae and thin horizontal beds that grade laterally into areas that contain convolute bedding with fold amplitudes about 30 cm (12 in.) in size. Outcrop weathers to light grayish purple.....	4.9	16.0
40.	Sandstone, lower 2.7 m (8.9 ft) concealed; calcareous in part; pale-yellowish-orange; very fine-grained to fine-grained, medium-grained within intervals that contain large-scale cross-bedding; well sorted, subrounded, partly indurated. Some large-scale trough cross-bedding interlayered with horizontal laminae; otherwise very thick-bedded; numerous fractures throughout unit oriented at high angles to bedding. Top 6 m (20 ft) of unit contains thin calcareous sandstone beds about 0.3 m (1 ft) thick showing tabular-planar cross-stratification. Weathered outcrop shows zones of sharp changes in cementation and color from well-indurated, pale-grayish-orange sandstone to friable very pale orange sandstone. Rare to common slickensided surfaces in more silica-cemented intervals.....	19.8	65.0
39.	Sandstone, grayish-orange, fine-grained; well-sorted, subrounded to rounded; partly indurated; horizontally laminated; highly fractured, slickensided surfaces common. Possible fault.....	1.2	4.0

		Thickness	
		Meters	Feet
38.	Sandstone, very calcareous; pale-yellowish-orange and light-gray; locally siliceous and interlayered with thin crystalline dolomite beds; well-indurated, some sparry calcite which occurs in fillings as much as 0.65 mm thick; some yellowish-orange iron oxide mottling; medium-bedded to thick-bedded; locally weathers to pinkish gray; centimeter-sized dissolution vugs more abundant near top of unit. Forms blocky ledge. Conodont sample locality 29737-PC.....	2.4	8.0
37.	Sandstone, very pale-orange; coarse-grained to medium-grained, subrounded to rounded; unit shows slight fining-upward in grain size; top poorly exposed.....	3.0	9.8
36.	Sandstone, pale-grayish-orange to yellowish-orange; fine-grained, well-sorted, subrounded to rounded; mostly friable; thin-bedded to thick bedded with large-scale trough cross-beds, set height approximately 1 m (3.3 ft); top of unit shows some medium-scale tabular-planar cross-stratification and very thin horizontal laminae. Top forms poorly exposed bench.....	2.9	9.5
35.	Sandstone, very pale-grayish-orange, weathers light gray to pale grayish orange; partly calcareous; medium- to fine-grained; mostly friable; lower part poorly exposed. Upper part is very thin-bedded and irregularly laminated; some tabular-planar cross-laminae containing set heights about 20 cm (7.8 in.) and tabular-planar cross-beds with set heights approximately 1 to 2 m (3.3 to 6.6 ft); convolute laminae occur locally; may be well indurated at places near top of unit; distincitve iron oxide staining along laminae traces. Upper contact not exposed.....	6.7	22.0
34.	Sandstone, pale-yellowish-orange, weathers to grayish orange pink-colored regolith; very fine grained to fine grained; partly indurated and irregularly cemented; base is horizontally laminated; ripple laminated at some places, overlain by low-angle tabular-planar cross-laminae. Top is poorly exposed.....	3.0	10.0
33.	Sandstone, partly concealed, very light-gray; possibly very thick bedded; well indurated in places. Top of unit is very fine grained, carbonate cemented and weathers pale yellowish orange.....	1.2	4.0

		Thickness	
		Meters	Feet
32.	Sandstone, very pale-orange; calcareous in part; medium- to fine-grained, moderately well sorted, subrounded to rounded; variably cemented; lower part is very thin to thick bedded; middle part is horizontally laminated with distinctive iron oxide staining and rare ripple laminae; upper part is poorly exposed, probably weakly indurated, very pale-orange to light gray sandstone; some spheroidal weathering on outcrop similar to unit 51.....	3.7	12.0
31.	Sandstone grayish-orange; medium- to fine-grained, well-indurated; very thin-bedded, grades vertically into very pale-yellowish-orange, moderately to well-sorted, subrounded to rounded sandstone; locally, extremely friable; some wedge-planar and tabular-planar cross-stratification, set height between 5 and 10 cm (2 to 4 in.); some thin centimeter-sized calcite-filled fractures oriented at high angles to bedding. Uppermost part of unit is extremely friable and weathers to dark yellowish orange to very pale orange; irregular horizontal laminae; some iron oxide staining along laminae.....	6.1	20.0
30.	Sandstone, locally may be quite vitreous due to extensive silica cementation; mostly fractured with abundant slickenside surfaces and fractures oriented at high angles to bedding. Estimated thickness.....	3.0	10.0
29.	Sandstone, pale-yellowish-orange to yellowish-gray; medium- to fine-grained, well-sorted, subrounded; partly indurated; distinctive spheroidal weathering on outcrop.....	1.5	5.0
28.	Siltstone and very fine-grained sandstone, carbonate-cemented; grayish-orange to medium-light-gray; weathers to light gray; quartz occurs locally in recrystallized carbonate matrix. Sandstone is moderately to poorly sorted with angular to subrounded grains; irregular ripple laminae; some calcite fillings as much as about 1 cm ($1/4$ in.) in diameter. Upper part of unit grades upward into pale-yellowish-orange, fine-grained calcareous, well-indurated sandstone containing mostly very thin beds and horizontal laminae.....	1.1	3.5

		Thickness	
		Meters	Feet
27.	Sandstone, lower third of unit is grayish-yellow, fine grained, friable, probably very thin bedded; poorly exposed at base and is capped by dolomitic sandstone. Middle third of unit weathers grayish yellow to light gray; mostly fine-grained; poorly exposed; upper third of unit contains very pale-orange to pale-yellowish-orange, medium- to fine-grained poorly indurated sandstone; mostly thin to medium bedded; some planar cross-laminae overlain at the top of the unit by calcareous very pale-orange, very-fine grained sandstone.....	6.4	21.0
26.	Sandstone, very pale-orange, weathers light gray; fine grained, well sorted; friable in part; bedding poorly exposed. Forms slope.....	0.5	1.5
25.	Sandstone, pale-yellowish-orange; calcareous in part; medium-grained to fine-grained, well-sorted, subrounded to rounded; partly indurated; mostly horizontally laminated and very thin bedded with some small-scale tabular-planar cross-laminae, set height about 3.5 cm (1.4 in.); locally may be massively bedded; iron oxide staining along laminae traces is common. Forms minor ledges.....	4.9	16.0
24.	Dolostone, yellowish-gray to medium light-gray; indistinct bedding; weathers to grayish orange; forms thin blocky ledge; sharp contact with overlying sandstone.....	0.2	0.8
23.	Sandstone, dolomitic and calcareous; very light-gray to white; weathers light gray; medium grained to fine grained, moderately well sorted to well sorted; subangular to subrounded; indurated in part; very thin horizontal beds; contact with overlying dolostone is gradational; lower part of unit is mostly sandy dolostone, yellowish gray, weathers to light gray and pale yellowish brown; quartz is very fine to medium grained; poorly sorted, subrounded to rounded; well indurated, irregularly and wavy laminated; cherty. Base of unit is dolomicrite, sandy in part, medium light gray to pale yellowish orange weathers to very light bluish gray. Poorly exposed, probably medium bedded. Forms blocky ledge.....	8.2	27.0

	Thickness	
	Meters	Feet
22. Sandstone, very pale-yellowish-orange, weathers to light gray, calcareous in part; fine grained very well sorted mostly subrounded, moderately indurated; some iron oxide staining along bedding surfaces, occasional iron oxide halos as much as 0.5 cm (0.2 in.) in diameter; some low-angle trough cross-beds and very thin horizontal plane beds. Top of unit is poorly exposed.....	6.1	20.0

Traverse offset from point B to point C along Big Sheep Creek Canyon (fig. 5).

21. Sandstone, weathers pale yellowish orange to dark yellowish orange; fine grained, well sorted; friable in part; medium-scale wedge-planar and tabular-planar cross-beds (set height=0.5 m); cross-beds have an average dip direction of N. 12 E.; cross-stratification increasingly larger in set height and more abundant near top. Forms cliff.....	3.7	12.0
20. Sandstone, part calcite and dolomite cemented; light gray; fine-grained; contains wavy-laminated and low-angle small-scale tabular-planar and wedge-planar cross-laminae; interbedded with discontinuous thin beds of dolostone; grades laterally into dolomitic sandstone. Forms minor ledge.....	3.0	10.0
Total Sandstone member.....	527.7	1731.9

Dolostone member:

19. Sandstone, calcareous; light-gray, fine-grained, moderately well-sorted; thin-bedded and laminated; cherty dolostone in upper half; occasional sparry calcite fillings several centimeters in diameter. Forms minor ledge.....	2.5	8.1
18. Dolostone, sandy, about 20 percent quartz; light-gray; lenticular to wavy laminated.....	0.9	3.0
17. Dolomicrite, sparsely bioclastic; medium-dark-gray to dark-gray; some nodular chert as much as 10 cm (3.9 in.) across. Forms minor ledge. Conodont sample locality 29736-PC.....	1.7	5.6

		Thickness	
		Meters	Feet
16.	Dolostone, and thin interbedded sandy dolostone, medium-light-gray and light-gray, weathers very light gray; scattered bioclasts some of which are as much as 5 mm in size; some iron oxide concretions 3-5 cm (1 1/2 in.) in diameter. Top of unit forms poorly exposed slope.....	2.7	8.8
15.	Sandstone, calcareous, very pale-orange, weathers very pale orange to light gray; fine-grained, moderately well sorted; low-angle tabular-planar and horizontal-planar laminated cross-beds.....	2.4	7.9
14.	Dolostone, light-gray, weathers pale yellowish gray; scattered fine bioclasts as much as 5 mm in size; interbedded sandy dolostone containing about 50 percent quartz as distinctive lenticular laminae; unit shows fining-upward into light-gray dolomicrite. Forms minor ledge. Conodont sample locality 29735-PC.....	2.1	7.0
13.	Sandstone, dolomitic, light-gray to pale-yellowish-orange; grades upward into medium-dark-gray sandy dolostone with as much as 30 percent quartz in upper part; slightly fetid on fresh surface; some fine-grained bioclasts.....	1.6	5.1
12.	Dolostone and sandy dolostone, poorly exposed....	0.9	2.9
11.	Dolostone, sandy, about 30 percent quartz; medium-dark-gray, weathers yellowish gray to light olive gray; scattered bioclasts. Top is limestone (packstone) with 3 cm (1.2 in.) thick layer of brachiopod fragments. Unit forms poorly exposed thin ledges.....	1.2	4.0
10.	Sandstone, calcareous, pale-yellowish-orange, fine-grained very well-sorted low-angle tabular-planar accretionary cross-beds; cross-beds have an average dip direction of S. 52 W.; top 0.5 m (1.6 ft) is planar-laminated. Forms minor ledge.....	3.0	10.0
9.	Dolostone, medium-light-gray, weathers yellowish gray to light olive gray; scattererd bioclasts.....	1.1	3.6
8.	Siltstone and very fine-grained sandstone, dolomitic; medium-light-gray weathers pale yellowish orange; thin-bedded at base to medium-bedded and ripple laminated at top; unit varies laterally to sandy and silty dolostone; locally top of unit is very thick bedded and contains disseminated bioclasts.....	1.5	5.0

	Thickness	
	Meters	Feet
7. Dolomicrite, medium-light-gray weathers yellowish gray; irregularly laminated and somewhat bioturbated; unit contains rare bioclasts as much as about 2 cm (3/4 in.) in size; organic-rich in places; coarsens upward to bioclastic limestone (packstone) which is organic-rich; intercalated with thin beds of dolomitic sandstone. Conodont sample locality 29734-PC	2.2	7.2
6. Dolostone, sandy, and calcareous sandstone, weathers grayish orange; irregularly laminated and bioturbated; increasingly organic rich toward top	1.2	4.1
5. Sandstone, weathers light gray; fine grained, moderately well sorted, subangular; ripple laminated and bioturbated; interbedded dolostone containg dark-bluish-gray chert nodules and lenses as much as 5 cm (2 in.) in diameter	2.5	8.3
4. Sandstone, calcareous, weathers pale yellowish orange and is marked by conspicuous purplish liesegang bands; cross-laminated with high-angle trough cross-beds at base	0.9	3.0
3. Sandstone, very pale-orange, calcareous, weathers light gray; fine grained, moderatley well sorted; friable in part; some interbedded dolostone and sandy dolostone. Poorly exposed at base. Forms slope	10.9	35.9
2. Dolostone, sandy, about 50 percent quartz with lesser amounts of sandy limestone (wackestone); weathers very pale orange; planar laminated; poorly exposed	4.1	13.4
1. Dolomicrite, sandy, interbedded with limestone (wackestone); weathers light olive gray and medium light gray; laminated to thin bedded; poorly exposed	9.4	30.7
Total Dolostone member	52.8	173.6
Total Quadrant Sandstone	580.5	1905.6
Amsden Group (Pennsylvanian):		
Alaska Bench Limestone:	Not measured	

DALYS SPUR (3)
Dalys Spur 7 1/2´ Quadrangle
SW 1/4 sec. 36 T. 8 S., R. 10 W.

Exposures of the Quadrant Sandstone at Dalys Spur (locality 3; figs. 1 and 6) are from a partial stratigrahic section revealing approximately only the upper third of the formation. A north to south-trending normal fault parallels a short canyon reach of the Beaverhead River and separates the Pennsylvanian Quadrant Sandstone on the west side from Triassic and younger rocks on the east side (Lowell, 1965). In years past, this locality was the site of a Quadrant Sandstone quarry from which rock was shipped by rail north to smelters at Anoconda for processing as flux and ore converter linings (Klepper, 1950).

The section at Dalys Spur was measured and described along the base of cliffs that form the west wall of the Beaverhead River canyon (fig. 6). The exposures are immediately south of the confluence of Grasshopper Creek. The base of the section is located along old highway 91 accessible via the Barretts interchange along Interstate 15, approximately 13 km (8 mi) southwest of Dillon Montana. The traverse begins at point A (fig. 6 and proceeds to point B at the south end of the canyon above old highway 91, and onto the large dipslope that reveals the contact between the upper Quadrant and the lower part of the Phosphoria Formation. Here the phosphatic mudstones of the Retort and Meade Peak Members of the Phosphoria are exposed in a swale among older phosphate trenches and workings (point C) (Cressman and Swanson, 1964, p. 408-413, p. 20).

Phosphoria Formation (Permian) [incomplete]:
Rex Chert Member:

	Thickness	
	Meters	Feet
10. Chert, massive; forms resistant ridge.....	Not measured	
Meade Peak Phosphatic Shale Member:		
9. Sandstone and phosphatic(?) siltstone, buff; very fine-grained; thin-bedded at base; possibly mudcracked.....	Not measured	
8. Mudstone, phosphatic, yellowish-gray.....	0.5	1.8
7. Siltstone, phosphatic, light-gray.....	0.3	0.9
Park City Formation (Permian)		
Grandear Member:		
6. Sandstone, medium-grained; ripple-laminated to bioturbated; prominent iron oxide staining.....	0.4	1.4
5. Sandstone, very light-gray; medium- to fine-grained; argillaceous; irregularly laminated; contains thin fining-up intervals about 5 cm (2 in.) thick.....	0.2	0.8
4. Chert-pebble conglomerate, chert and quartzite pebble-sized clasts; some fine and medium-grained sandstone, poorly sorted; some lenticular chert masses; slightly argillaceous.....	2.7	9.0

	Thickness	
	Meters	Feet
3. Poorly exposed, probably cherty dolostone and sandstone.....	2.6	8.6
2. Dolostone, sandy, very pale-orange; somewhat friable and thick-bedded; overlain by dolostone, very pale-orange with lenticular chert nodules as much as about 30 cm (12 in.) in diameter.....	0.7	2.2
1. Lower part of unit contains sandstone and chert-granule conglomerate; weathers moderately brown; moderate to poorly sorted; some fine-grained sandstone but mostly granule- to very coarse-grained chert and quartz occurring as channel lag at base of fining upward sequence; laterally grades into medium-grained sandstone of Quadrant Sandstone units 5 and 4; top of unit contains pale yellowish-orange fine-grained sandstone.....	3.5	11.5
Total measured part of Phosphoria and Park City Formations...	10.9+	36.2+
Quadrant Sandstone (Pennsylvanian):		
Sandstone member:		
5. Sandstone, very pale-orange; carbonate-cemented in places; fine- to medium-grained; some chert layering and dolomitic sandstone, very fine grained.....	1.2	3.8
4. Sandstone, medium-grained; lithology similar to units below; mostly large-scale wedge-planar and tabular-planar cross-beds; set heights ranges from 1 to 10 m (3.3 to 33 ft) rare large-scale trough cross-beds. Cross-beds have an average dip direction of S. 17 E., Estimated thickness.....	3.0	10.0
3. Sandstone, fine- to medium-grained and some coarse-grained sand; well-sorted, subangular; friable in part; mostly horizontally laminated; somewhat argillaceous within segregated sets of medium- and fine-grained laminated couplets about 6 to 10 cm (2.3 to 3.9 in.) thick; some tabular-planar cross-bedding with set heights about 1 m (3.3 ft) showing graded foresets and rare intercalated very fine- to fine-grained irregular ripple laminae; somewhat bioturbated and locally may be cherty. Iron oxide stains occur as halos measuring as much as about 10 cm (4 in.) in diameter in lower part of unit. Forms bold cliff. Estimated thickness.....	9.1	30.0

	Thickness	
	Meters	Feet
2. Sandstone, fine- to medium grained; friable; some large-scale tabular-planar and wedge-planar cross-bed sets; set height about 2 to 5 m (6.6 to 16.4 ft); some liesegang bands and horizontal laminae showing segregated medium- and fine-grained layering; coarser grained layers contain white argillaceous material; thick-bedded. Forms bold cliffs. Cross-beds have an average dip direction of S. 02 E. Estimated thickness.....	82.3	270.0
1. Lower part of section not present due to faulting.....	Not measured	
Total measured part of Sandstone member.....	95.6	313.8+

ARMSTEAD (4)
Garfield Canyon 7 1/2 Quadrangle
NW 1/4 SW 1/4 sec. 11 T. 10 S., R. 10 W.

The Armstead section (locality 4, figs. 1 and 7) is located at the south end of the western flank of the Armstead Anticline near the upstream junction of Horse Prairie Creek and Clark Canyon Reservoir. The section begins at the base of an elongate ridge (point A) approximately 61 m (200 ft) north of highway 324 approximately 8 km (5 mi) west of the Clark Canyon Dam. The traverse proceeds upsection through discontinuous exposures of the Alaska Bench Limestone and carbonate rocks of the lower Dolostone member of the Quadrant Sandstone. The section continues around the south end of the talus-covered ridge onto the west side where both topography and structural dips are steep thus preventing further measurement (point B). Total thickness of the Quadrant Sandstone is extrapolated from nearby measurements to the east by Hildreth 1980, p. 101; and to the north by Lowell 1965.

Quadrant Sandstone (Pennsylvanian):
Sandstone member [incomplete]:

		Thickness	
		Meters	Feet
21.	Sandstone, and locally quartzite, fine- to medium-grained; vitreous; outcrops form mostly talus slopes and discontinuous cliff-forming ridges; dips nearly vertical to overturned along west side of ridge; top contact with Phosphoria Formation not exposed. Estimated thickness for unit base on measurements from nearby areas (Lowell, 1965; Hildreth, 1980).....	274.3	900.0
20.	Sandstone, slightly dolomitic; moderately sorted; ripple-laminated and tabular-planar cross-laminated.....	0.9	3.0
19.	Sandstone, extremely vitreous; fine-grained, well-sorted; forms steep talus-covered ledge; highly fractured. Estimated thickness.....	1.6	5.1
18.	Poorly exposed, probably sandstone and dolomitic sandstone.....	11.0	36.0
17.	Sandstone, pale-yellowish-orange; fine-grained, well-sorted; rounded; predominantly medium bedded; top is brecciated and contains numerous slickensided surfaces.....	0.9	3.0
16.	Sandstone, pale-yellowish-orange to buff; siliceous and well indurated although locally may be friable; fine grained, well sorted, rounded; top of unit is dolomitic and contains chert lentils 3 cm by 50 cm (1.2 by 20 in.) in size; well-developed jointing throughout unit obscures bedding details.....	7.9	26.0

	Thickness	
	Meters	Feet
15. Poorly exposed, mostly sandstone and quartzite talus-coverd slopes; isolated outcrops show fine- to medium-grained, slightly dolomitic sandstone containing small-scale low-angle cross-stratification, set height approximately about 5 cm (2 in.)....	7.3	24.0
14. Partly covered, probably sandstone, dolomitic; fine-grained to medium-grained; horizontally laminated to low-angle cross-laminated; possibly contains bioturbated layers; some interbedded quartz-poor dolostone; poorly exposed because of talus-covered hillside. Estimated thickness.....	12.8	42.0
Total measured part of Sandstone member.....	316.7	1039.1
Dolostone member:		
13. Dolostone, sandy, and interbedded sandstone; pale-yellowish-orange; fine-grained, well-sorted, well-indurated; cross-bedded; grades laterallly into dolostone and dolomitic sandstone; locally, dolostone may be ripple to horizontally laminated.....	4.2	13.7
12. Dolostone, slightly sandy; thin-bedded.....	0.6	2.0
11. Dolostone, sandy and dolomicrite, weathers very pale orange; well indurated; contains nodular to massive chert; some sandy interbeds.....	7.9	26.0
10. Dolostone and thin-bedded chert, weathers pale yellowish orange; chert occurs as nodules or lenticular masses as much as 10 cm (3.9 in.) thick and several meters in length; outcrop consists of as much as 50 percent chert.....	3.7	12.0
9. Poorly exposed, probably sandy dolostone.....	0.8	2.5
8. Dolostone, weathers very pale orange; well indurated; chert interbedded with dolomitic sandstone; seems to be thick bedded.....	1.6	5.1
7. Poorly exposed, probably sandy dolostone and dolomitic sandstone. Estimated thickness.....	6.1	20.0
6. Dolostone, varicolored; very pale-red to light-gray; silty at top; contains wavy laminae; medium bedded.....	0.6	2.0
5. Poorly exposed, probably dolomitic sandstone; buff to light-gray; probably finely laminated; may be gradational with unit above.....	0.5	1.8

	Thickness	
	Meters	Feet
4. Sandstone, dolomitic and siltstone, grayish orange; sandstone is very fine grained to fine grained, moderately sorted; well indurated; medium bedded and contains rare bioclasts; bioturbated; coarsens upward slightly	1.6	5.2
3. Dolomicrite, weathers grayish pink and yellowish gray; contains thin cherty beds	1.5	4.8
2. Dolostone, varicolored, light-gray to orange pink, weathers very pale orange; coarsely crystalline in places; well-indurated; possibly bioturbated; chert lenses measure as much as several meters in length and several centimeters thick	1.8	6.0
1. Dolostone, sandy, very pale-orange; finely laminated; poorly exposed. Estimated thickness	7.6	25.0
Total Dolostone member	38.4	126.1
Total Quadrant Sandstone measured	355.1	1165.2
Amsden Formation (Pennsylvanian):		
Alaska Bench Limestone [incomplete]:		
4. Poorly exposed; probably dolostone and limestone. Estimated thickness	10.4	34.0
3. Limestone, medium light-gray (packstone); pelloidal and coarsely bioclastic in part; nodular chert occurs in about 5 cm by 2 cm (2 by 0.8 in.) sized masses; contains some sparry calcite; local dolomitic and cherty replacement of skeletal fragments	2.4	8.0
2. Siltstone, light-reddish-orange to grayish-orange and fine-grained sandstone; very thin-bedded to laminated with occasional ripple bedding; base is fine grained, horizontally laminated sandstone that fines upward	4.6	15.0
1. Dolomicrite, light-olive-gray; medium-bedded; irregular mottling near top	1.1	3.5
Total measured part of Alaska Bench Limestone	18.5+	60.5+

CLOVER DIVIDE (5)
Whiskey Spring 7 1/2' Quadrangle
S 1/2 sec. 26 T. 12 S., R. 6 W.

The Clover Divide section (locality 5, figs. 1 and 8) is 43 km (27 mi) east of Lima, Montana and 59 km (37 mi) south of Dillon, Montana. Poorly exposed outcrops of the Quadrant Sandstone are located on the east side of the West Fork Blacktail Deer Creek in the southern Snowcrest Range. Most of the strata here are strongly folded along the Snowcrest-Greenhorn structural trend. The stratigraphic section begins within the Alaska Bench limestone 122 m (400 ft) east of the 7,160 foot benchmark on the Blacktail Deer Creek Road (point A) and proceeds due south through mostly grassy covered hillslope and isolated sandstone outcrops to cherty beds of the Permian Phosphoria Formation in the SW 1/4 SE 1/4 of section 26 (point B). Relevant stratigraphic and structural interpretations for this area are those by Klepper (1950), and Zeigler (1954, p. 124). The Phosphoria and Park City Formations in this area have been described by Cressman and Swanson (1964, p. 500-505, plate 21).

Park City and Phosphoria Formations undivided (Permian) [incomplete]:

	Thickness	
	Meters	Feet
3. Dolostone, poorly exposed, float contains numerous egg-sized chert nodules.....	Not measured	
2. Covered, mostly dolostone, sandstone, and chert..	7.6	24.8
1. Dolostone, light-gray to buff; coarsely crystalline. Conodont sample locality 29755-PC.....	1.2	4.0
Total measured part of Park City and Phosphoria Formations...	8.8	28.8+

Quadrant Sandstone (Pennsylvanian):
Sandstone and dolostone members - undivided:

11. Sandstone, calcareous; irregular and disrupted bedding; base not exposed.....	1.1	3.5
10. Sandstone, pale-yellowish-orange to dark-yellowish orange, weathers light gray; medium to fine grained; friable; slightly argillaceous; cross-stratified, medium- to thick-bedded; poorly exposed in places; abundant slickensided surfaces on joint planes oriented at high angles to bedding.....	4.6	15.0

		Thickness	
		Meters	Feet
9.	Poorly exposed; lower part of unit is mostly sandstone that weathers plae yellowish orange to yellowish orange; fine grained; some tabular-planar and wedge-planar cross-laminae; set height about 2 m (6.6 ft); cross-beds have an average dip direction of S. 48 W.; some laminae are gently undulatory and show alternations of medium- and fine-grained segregated layers. Top of unit is covered; sandstone float in colluvium suggest the unit is probably moderately indurated light brownish gray weathering fine-grained sandstone; contains abundant finely fractured and slickensided sandstone fragments in float. Estimated thickness.....	66.8	219.3
8.	Dolostone, pale-yellowish-orange; hackly fracture	0.5	1.5
7.	Dolostone, cherty and carbonate-cemented sandstone. Base of unit contains cherty dolostone and is overlain by: dolostone breccia with clasts as much as 1 cm (0.4 in.) in size overlain by an irregular interval containing numerous nodules and stringers of chert overlain by carbonate-cemented sandstone and dolostone containing many sparry calcite-filled cavities and vugs, and capped by about 0.3 m (1 ft) of pinkish-gray, medium-bedded dolomitic sandstone (80 percent quartz) at top. Entire unit is lenticular and grades laterally into cross-bedded sandstone.....	1.4	4.5
6.	Sandstone, weathers pale yellowish orange, fine grained with sparry calcite nodules measuring less than 1 cm (0.4 in.) in diameter; medium bedded.....	1.1	3.5
5.	Sandstone and interbedded dolomitic sandstone; sandstone is mostly fine grained, variably indurated; dolomitic sandstone is well indurated and contains small nodular patches of calcareous dark yellowish orange sandstone. These areas seem disrupted by bioturbation; some thin, interbeds of medium-grained sandstone; abundant caliche throughout interval; high degree of vertical and lateral variation in lithology and cementation; prominent jointing throughout.....	4.6	15.0
4.	Sandstone, fine-grained, well-sorted, well-rounded; some disrupted laminae; silica cemented; moderately indurated.....	0.4	1.3

	Thickness	
	Meters	Feet
3. Sandstone and dolomitic sandstone, grayish-orange; medium-grained, well-sorted, rounded; some tabular-planar cross-bedding; prominent jointing on outcrop; poorly exposed.....	5.9	19.3
2. Poorly exposed, mostly sandstone, very light-gray to buff, weathers to pale yellow orange; some fine- to medium-grained sandstone, well-sorted, well-rounded; contains some cross-bedded intervals; cross-beds have an average dip direction of S. 38 W. Estimated thickness.....	32.0	105.0
1. Poorly exposed, mostly sandstone, weathers light gray, very pale orange, grayish orange, and light brown; float contains mostly fine-grained, well-sorted sandstone and slickensided sandstone fragments; variably cemented and locally contains prominent quartz-filled fractures. Exposed mostly as float on grassy hillslope. Estimated thickness.....	62.7	205.8
Total Sandstone and Dolostone member measured.....	181.1	593.7
Amsden Group (Pennsylvanian):		
Alaska Bench Limestone [incomplete]:		
2. Poorly exposed, mostly limestone, light-gray to very light gray; some patches of sparry calcite and vein-filling calcite; float occurs in grassy slope above creek. Estimated thickness.....	57.9	189.9
1. Poorly exposed, limestone, mostly crinoidal and brachiopod-bearing grainstone; some interlayered thin-bedded micritic limestone, dark gray, fetid on fresh surface; contains rare bioclasts, some strophomenids and wide-hinged brachiopod fragments; top 33 ft (10 m) concealed, probably limestone. Conodont sample locality 29754-PC.....	10.3+	33.7+
Total measured part of Alaska Bench Limestone.....	68.2+	222.6+

WIGWAM CREEK (6)
Varney 15′ Quadrangle
SE 1/4 sec. 33 and SW 1/4 sec. 34, T. 7 S., R. 2 W.
measured by H. I. Saperstone and E. K. Maughan

The Wigwam Creek section (locality 6, figs. 1 and 9) is located approximately 14 mi 22.5 km (14 mi) southwest of Ennis, Montana in the northern Gravelly Range, Madison County. Access is by way of unimproved road southwest of Gerand Ranch, north of Wigwam Creek. The section begins above the Madison Limestone whose beds are exposed in the steep north canyon wall of Wigwam Creek (point A). The traverse proceeds upslope to the top of the hill which is capped by the Permian Shedhorn Sandstone (point B) (fig. 9). The principal references for this section are those by Hadley (1969 and 1980, p. 46-58).

Shedhorn Sandstone (Permian) [incomplete]:

	Thickness Meters	Thickness Feet
3. Sandstone, conglomeratic; weathers pale brown; coarse grained to granular; some "salt and pepper" speckling due to light-gray chert grains admixed with quartz sand. Unit forms poorly exposed bench at top of hill.....	Not measured	
2. Sandstone, moderate reddish-brown; poorly sorted; locally may contain conspicuous coarse grains of gray chert; unit is interbedded with moderately sorted medium-grained sandstone and silty mudstone.....	6.1	20.0
1. Conglomerte and brecciated sandstone; medium-grained sand matrix supports subangular sandstone clasts as much as about 5 cm (2 in.) in size; calcite-cemented in part.....	0.6	2.0
Total measured part of Shedhorn Sandstone.....	6.7	22.0+

Quadrant Sandstone (Pennsylvanian):
Sandstone member:

31. Sandstone, yellowish-orange; fine- to medium-grained; well-sorted; subrounded; variably calcite and silica cemented. Contains tabular-planar cross-beds with set height about 1 m (3.3 ft) or less; cross-beds have an average dip direction of S. 52 W.; the upper 2.1 m (7 ft) contains some low-angle small scale trough cross-laminae and rare convolute laminae. Forms cliff.....	8.8	29.0
30. Dolostone, sandy, yellowish-gray and very light-gray containing scattered medium- to coarse-grained quartz and rare chert grains; locally, laminae may be irregularly rippled to contorted. Some grayish-orange limonite staining.....	0.8	2.5

	Thickness	
	Meters	Feet
29. Sandstone, same as lower part of unit 31; bounding surfaces are tightly cemented and may be silty in places	5.2	17.0
28. Poorly exposed; mostly moderate reddish-orange sandy regolith	0.3	1.0
27. Sandstone, very calcareous; fine- to medium-grained; massive to thick bedded with faint traces of large-scale cross-bedding	2.1	7.0
Total Sandstone member	17.2	56.5
Dolostone member:		
26. Poorly exposed, colluvium shows mostly moderate reddish-orange, fine-grained to medium-grained sand	1.5	5.0
25. Covered slope	5.5	18.0
24. Sandstone, calcareous; interbedded with very sandy dolostone, yellowish-gray, containing very fine-grained to fine-grained quartz. The base of this unit is thick to irregularly bedded, pale-red weathering sandy dolostone; scattered bioclasts in lower part; coarsens upward to fine-grained, medium-grained sandy dolostone	9.1	30.0
23. Poorly exposed, probably sandy dolomite and dolomitic sandstone	5.2	17.0
22. Sandstone, dolomitic, irregularly bedded	4.6	15.0
21. Dolostone, very sandy; yellowish-gray; weathers locally to a pitted surface; unit contains between 30 and 40 percent quartz; beds are irregular due to intraformational slumping and dissolution; locally, areas of massive and cross-laminated fine- to medium-grained well-sorted sandstone	0.6	2.0
20. Same as unit above; grades upward from sandy dolostone into dolomitic sandstone with horizontal laminae in lower part to massive irregular and low-angle cross-laminae in upper part	5.2	17.0
19. Same as unit 21 above but is sandier toward the top	6.1	20.0
18. Dolostone, silty and moderate orange-pink mudstone, containing irregular to wavy laminae; some birdseye fenestrae toward the top; contact with overlying unit is irregular. Forms reentrant in hillslope	1.1	3.5
17. Dolostone, sandy, pinkish-gray with hematitic and limonitic stains; mostly medium to thin bedded but contains some wavy (possibly algal) laminae	0.6	2.0

		Thickness	
		Meters	Feet
16.	Dolomicrite, slightly quartzose; light-gray; sparsely bioclastic; medium-bedded and brecciated in part; conspicuous mudstone partings at top of each bed.....	3.4	11.0
15.	Sandstone, very calcareous to dolomitic; irregular intervals of brecciation with some interlayered dolomicrite; areas of moderate reddish-orange mudstone-filled fractures at top of unit.....	3.7	12.0
14.	Breccia, irregular thickness, contains very angular dark-red siltstone and mudstone clasts similar to unit 11 below; clasts are as much as 10 cm (3.9 in.) in size.....	0.3	1.0
13.	Sandstone, calcareous and dolomitic, grayish-yellow; very fine-grainedE possibly some algal laminae. Similar lithology to unit 12 below; mostly medium- to thick-bedded.....	1.2	4.0
12.	Dolostone, sandy, calcareous, pinkish-gray with some sparry calcite cement; wavy laminae and some birdseye fenestrae; some fluting on base of beds; possibly bioturbated.....	0.3	0.9
11.	Siltstone, laterally heterogeneous and varicolored; mottled grayish orange to dark yellowish orange with areas of mostly grayish red and grayish purple. The base of the unit is mostly pale red and is calcareous toward the top; laminated throughout with some wavy laminae.....	0.3	1.0
10.	Siltstone, somewhat argillaceous and locally calcareous; mostly pale reddish-purple to pale-red; some scattered silicified bioclasts; medium bedded.....	5.2	17.0
9.	Sandstone, dolomitic with dolostone breccia at the base; mostly medium- to thick-bedded; somewhat bioturbated.....	1.8	6.0
8.	Mudstone, silty, calcareous interbedded with very silty pale-red and pale-reddish purple limestone; grades upward into fine-grained carbonate-cemented sandstone with uneven bedding. Forms resistant ledge.....	1.5	5.0
7.	Sandstone, dolomitic and interbedded sandy dolostone, dusky yellow; friable and variably cemented with calcite and dolomite; upper half is well-indurated, containing numerous sparry calcite-filled vugs and scattered brachipod fragments. Irregularly bedded throughout.....	6.4	21.0

	Thickness	
	Meters	Feet
6. Dolostone, sandy, somewhat calcareous, yellowish-gray; contains about 20 percent very fine-grained to silt-size quartz; thinly bedded with a few sparry calcite-filled vugs.....	0.9	3.0
5. Chert-pebble conglomerate, clasts of well-rounded, black, dark-red and pale-olive chert in a yellowish-gray dolomitic sandstone matrix.....	0.3	1.0
4. Poorly exposed, probably red mudstone.....	0.2	0.5
3. Limestone conglomerate, medium light-gray and mottled pale-red. Some sparry calcite matrix; clasts of limestone more concentrated near the top and are as much as 7 cm (2.7 in.) in diameter. Some chert clasts and silicified bioclasts grade upward from granule to fine-grained sand size; uppermost layer is variable in thickness (about 0.3 m or 1 ft) of intermixed reddish mudstone and siltstone.....	0.9	3.0
2. Sandstone, yellowish-orange; fine-grained; very calcareous; friable throughout; conspicuous yellow to light-brown iron oxide liesegang stains; some horizontal laminae.....	2.1	7.0
1. Sandstone, very calcareous, very fine-grained to silty; weathers moderate red with circular to ovoid iron oxide halos about 0.5 cm (1/4 in.) in diameter; possibly bioturbated.....	0.3	1.0
Total Dolostone member.....	68.3	223.9
Total Quadrant Sandstone.....	85.5	285.5
Madison Group (Mississippian):		
Mission Canyon Limestone [incomplete]:		
4. Limestone breccia, regolithic, containing clasts of pinkish- to yellowish-gray micritic limestone; many clasts ae fragmental and recemented with chert; matrix is predominantly very fine-grained sand admixed with mud. Some knobby weathering chert within dolomicrite in the uppermost part of the unit; contact with overlying unit is characterized by possible karstic surface with areas of reddish mud infilling. Thickness varies.....	4.9-7.3	16.0-24.0
3. Limestone, micritic, (mudstone); pinkish- to yellowish-gray with indistinct wavy laminae....	0.6	2.0

	Thickness	
	Meters	Feet
2. Limestone (wackestone), pinkish-gray, weathers medium light gray; contains fine bioclasts and some low-angle cross-laminae; grades upward into micritic limestone.....	1.7	5.5
1. Dolostone, calcareous, pale orange-pink, medium- to thin-bedded; horizontally laminated in beds about 5 to 10 cm (20 to 4 in.) thick.....	0.9	3.0
Total measured part of Mission Canyon Limestone.....	9.2+	30.5+

BIG HORN MOUNTAIN-BLACK BUTTE (7)
Monument Ridge 15′ Quadrangle
modified from Mann, 1954
NW 1/4 sec. 36, T. 10 S., R. 2 W. and NE 1/4 sec. 2, T. 11 S., R. 2 W.

The Big Horn Mountain-Black Butte section is located just east of the Gravelly Thrust System (locality 7, figs. 1 and 10) in the central Gravelly Range, Madison County. The area is accessed from the Madison Valley westward along Standard Creek or from the Gravelly Range Road located 0.8 km (1/2 mi) to the west of the Black Butte Ranger Station. This section is a composite description of two section traverses one of which is a partly exposed section located 0.4 km (1/4 mi) south of the Black Butte Ranger Station and the other is a relatively complete section located along the crest of the north facing cirque wall at Big Horn Mountain (Mann, 1954, p. 80-81). The section at Big Horn Mountain begins at point A (fig. 10) and proceeds NW along a narrow ridge to point B. Additional references are those by Hadley (1969 and 1980, p. 48).

Shedhorn Sandstone (Permian) [incomplete]:

	Thickness	
	Meters	Feet
2. Sandstone, quartzitic, medium dark gray; fine-grained; bedding indistinct; chert nodules common; forms ledge.....	Not measured	
1. Dolostone, medium light-gray, well indurated, massive; forms slope.....	1.8	6.0
Total measured part of Shedhorn Sandstone.....	1.8+	6.0+

Quadrant Sandstone (Pennsylvanian):

Sandstone member:

16. Sandstone, grayish-orange to light-gray and white; fine- to medium-grained; extensively silica-cemented and well indurated but may be calcareous locally; some brecciation. Unit contains low-angle small-scale tabular-planar cross-beds. Forms talus slope.....	13.4	44.0
15. Sandstone, grayish-orange to light-gray; fine- to medium-grained; siliceous, but may be locally calcareous or dolomitic; thick- to massive-bedded; medium- to large-scale high-angle cross-beds about 3 to 5 m (9.8 to 16.4 ft) in set height. Cross-beds have an average dip direction of S. 27 E.; unit forms bold cliff.....	22.9	75.0
14. Sandstone, light gray to white; fine-grained, thin-bedded; some brecciation near base; two 10 cm (3.9 in.) beds of light-gray, dense dolostone in lower part. Forms cliff....	12.2	40.0
Total Sandstone member.....	48.5	159.0

	Thickness	
	Meters	Feet
Dolostone member:		
13. Partly exposed, sandstone, weathers light red to dark yellowish orange to light gray; well indurated and siliceous but may be locally calcareous; small-scale wedge-planar and tabular-planar cross-beds containing set heights about 25 cm (9.8 in.); minor trough cross-beds; unit forms varicolored ledges.....	1.8	6.0
12. Sandstone and dolostone; stained red on outcrop. Sandstone is highly fractured but contains recognizable low-angle tabular-planar cross-beds; locally, dolostone contains chert breccia and rare chert nodules; unit also contains some very thin-bedded reddish purple mudstone and shale. Forms poorly exposed talus-covered ledges.....	4.9	16.0
11. Sandstone, light-gray; highly fractured similar to unit 12 above; intercalated with light-gray well-indurated dolostone. Forms poorly exposed blocky weathering slope.....	6.4	21.0
10. Poorly exposed; float contains light-gray, very fine-grained silica cemented sandstone....	4.0	13.0
9. Sandstone, white to grayish-orange, fine-grained; locally silica-cemented; massive, distinctive reticulated boxwork texture resulting from selective weathering of breccia fragments.....	16.5	54.0
8. Sandstone, dusky red, fine-grained; forms ledge..	0.9	3.0
7. Sandstone, moderate red, fine-grained, thin-bedded and contains thin dolomitic breccia.....	0.6	2.0
6. Shale, dusky red.....	0.3	1.0
5. Sandstone, weathers light gray to pale yellowish orange; well sorted and well rounded; silica cemented; seems mostly horizontally laminated and contains tabular-planar and wedge-planar cross-beds; set heights are less than 1 m (3.3 ft). Presence of dolomicrite breccia are indicated by float.....	38.1	125.0
4. Sandstone, white to pale-yellowish orange, locally purplish; fine-grained; medium-bedded, contains some thin beds of grayish-orange well-indurated dolostone. Forms slope.....	9.1	30.0
3. Sandstone, medium light-gray to grayish-orange, locally moderate red; medium- to thick-bedded; interbedded sandstone and grayish-orange, well-indurated dolostone in lower part.....	19.5	64.0

	Thickness	
	Meters	Feet
2. Dolostone, grayish-orange to light-gray, well-indurated; medium-bedded; contains several thin beds of grayish-orange, fine-grained silica-cemented sandstone; brecciated dolostone clasts in sandy calcareous matrix in basal meter of unit.....	4.6	15.0
1. Dolostone, grayish-orange to light-gray, well-indurated, massive to low-angle cross-bedded; contains five thin calcareous grayish-orange sandstone beds with minor reddish argillaceous to silty sandstone interbeds. Forms ledge.....	7.0	23.0
Total Dolostone member.....	113.7	373.0
Total Quadrant Sandstone.....	162.2	532.0
Big Snowy Formation (Mississippian) [incomplete]:		
1. Limestone medium-dark-gray, oolitic.....	Not measured	
Total measured part of Big Snowy Formation.....	Not measured	

ODELL CREEK (8)
Lower Red Rock Lake 15′ Quadrangle
SW 1/4 sec. 6, T. 15 S., R. 1 W., and SE 1/4 sec. 1, T. 15 S., R. 2 W.

The Odell Creek section (figs. 1 and 11) is located in the central part of the Centennial Mountains 5.6 km (3.5 mi) south of the town of Lakeview, Montana in southern Beaverhead County. The section is reached by vehicle from the Centennial Valley to the mouth of Odell Creek Canyon where local landowners may permit access for continued travel by foot or horse. At the junction of Odell Creek and its eastern tributary in NW 1/4 of section 6, (point A) (fig. 11) proceed southward along Odell Creek. Although the Quadrant Sandstone outcrops poorly, the stratigraphic sequence is relatively complete and is best viewed along the west bank of Odell Creek. Here, upper Paleozoic and Mesozoic rocks are gently arched along a southwest plunging anticline less than 1.6 km (1 mi) east of the Odell Creek Fault. The principal reference for this area is a geologic map by Witkind and Prostka (1977).

Park City Formation (Permian) [incomplete]:
Grandeur Member:

	Thickness	
	Meters	Feet
1. Poorly exposed, float contains very platy calcareous siltstone and chert fragments.....	Not measured	

Quadrant Sandstone (Pennsylvanian):
Sandstone member: absent

17. Poorly exposed; probably interbedded dolostone and well-indurated silica-cemented sandstone; rock fragments in colluvium suggest unit is more quartzose toward top of covered interval. Estimated thickness.....	10.7	35.0
16. Dolostone, sandy (as much as 20 percent subangular quartz); weathers pale yellowish-orange; coarsely crystalline; rare carbonate bioclasts; irregular and horizontal laminae at base of unit; top shows low-angle cross-stratification.....	0.7	2.3
15. Poorly exposed, probably dolomitic sandstone and siltstone; lower part contains siltstone and upper part contains mostly dolostone and sandy dolostone. Conodont sample locality 29753-PC.....	3.0	10.0
14. Sandstone, dolomitic, increasingly siliceous and finer-grained upward. Irregularly to very thin-bedded.....	0.5	1.5
13. Siltstone,argillaceous, weathers yellowish-orange; platy-bedded; interbedded with sandstone as above.....	1.2	4.0
12. Sandstone, light-gray, weathers pale yellowish orange; well indurated; unit grades upward to silty sandstone; top is ripple-laminated.....	0.3	1.0

		Thickness	
		Meters	Feet
11.	Dolostone, sandy, light-gray, weathers bluish light gray; moderately sorted; horizontally laminated.....	0.2	0.8
10.	Sandstone, fine-grained; siliceous.....	0.7	2.2
9.	Dolostone, sandy (as much as 30 percent quartz); coarsely crystalline in part; interlayered cherty lenses 3 by 15 cm (1.2 by 5.9 in.) in dimension; some low-angle cross-laminae in middle part and ripple-laminae in upper part; set height about 10 cm (3.9 in.); a few bioclasts occur along faint laminae near top of unit.....	1.2	4.0
8.	Dolostone, very light-gray to very pale-orange; contains areas of replacement chert; fossiliferous; contains calcite nodules as much as 1 cm (0.4 in.) in diameter; irregularly bedded; white-weathering dolomicrite at top. Conodont sample locality 29752-PC.....	2.9	9.5
7.	Covered.....	1.8	6.0
6.	Dolostone, light-gray; locally contains sparry calcite fillings; dolostone is in sharp contact with interbedded brownish-orange sandstone. Conodont sample locality 29751-PC.....	0.9	3.0
5.	Poorly exposed, probably interbedded dolostone and sandstone.....	2.7	9.0
4.	Sandstone, yellowish-gray, weathers very pale brown; fine grained; moderately to well sorted; well indurated. At top, unit becomes slightly coarser grained and increasingly dolomitic; mostly horizontally to irregularly laminated; very thin bedded.....	0.9	3.0
3.	Poorly exposed, soil contains light-red sandstone and siltstone chips.....	6.5	21.2
2.	Sandstone, dark yellowish-orange, weathers light gray; fine-grained; moderately sorted; patchy silcia cement, however top of unit is dolomitic; entire unit is thin-bedded with intercalated light-gray coarsely crystalline dolostone; sandstone contains some low-angle tabular-planar cross-laminae.....	3.4	11.0

	Thickness	
	Meters	Feet
1. Dolostone, light-gray, weathers very light gray; interbedded with light-gray coarsely crystalline dolostone; contains a few interlayered chert pods and bioclasts; partly horizontallly laminated and wavy, (possibly algal) laminted. Top of unit is concealed.....	4.7	15.3
Total Quadrant Sandstone.....	42.3	138.8
Madison Group (Mississippian):		
Mission Canyon Limestone [incomplete]:		
1. Dolostone, grayish yellowish-white to light-gray, medium- to very thick-bedded, locally massive. Unit is distinctively coarsely crystalline and contains interlayered chert lenses; intensely fractured and brecciated in part. Locally, top of unit is overlain by a very thin interval of reddish-brown mudstone and sandtone that may be the Kibbey Formation.....	Not measured	
Total measured part of Mission Canyon Limestone.....	Not measured	

CINNABAR MOUNTAIN (9)
Miner 15′ Quadrangle
NW 1/4 sec. 31, T. 8 S., R. 8 E.

The Cinnabar Mountain section is located about 8 km (5 mi) northwest of Gardiner, Montana in the southern Gallatin Range (locality 9, fig. 12). Vertically tilted Devonian through Cretaceous rocks, referred to as "Devils Slide", are exposed along a spectacular cliff on the southeast flank of Cinnabar Mountain located about 0.8 km (1/2 mi) west of the Yellowstone River and Highway 89. The section of yellowish-weathering Pennsylvanian Quadrant Sandstone stands in relief with subjacent Mississippian Big Snowy Formation (point A) and the superjacent dark shales and sandstone of Permian age. The upper contact with the Shedhorn Sandstone is well exposed (point B). The true thickness for these strata appears attenuated due to folding. Descriptions of the basal Permian strata are emmended from observations by Cressman and Swanson, (1964) pl. 21 and p. 547 and from Maughan (written communication). Access to the Cinnabar Mountain section is 6 mi (9.6 km) northwest from Gardiner, Montana via the old entrance road into Yellowstone National Park along the west side of the Yellowstone River (fig. 12). Geology taken from Calvert (1912) and Roberts (1972).

	Thickness	
	Meters	Feet
Phosphoria Formation (Permian):		
Retort Member [incomplete]:		
2. Chert-apatite pebble conglomerate, dark gray to black granule and pebble sized clasts; moderate to very poorly sorted; some chert is well rounded; weathers medium to dark gray. Sharp contact at base of unit.....	0.4	1.5
Lower member of Shedhorn Sandstone:		
1. Sandstone, dolomitic, very fine-grained, mostly light-olive gray; becomes conglomeratic toward top; conglomeratic subunit contains grains that are predominantly apatite pellets as much as 2.5 cm (1 in.) in diameter, mostly light olive gray to pinkish gray; massive bedded.....	0.5	1.6
Total measured part of Shedhorn Sandstone and Phosphoria Formation.....	0.9	3.1+
Quadrant Sandstone (Pennsylvanian):		
Sandstone member:		
5. Sandstone, medium-grained, weathers yellowish gray to light gray; irregularly to horizontally laminated; appears more irregularly bedded and bioturbated than units below. Estimated thickness.....	15.2	50.0

	Thickness	
	Meters	Feet
4. Sandstone, medium- to fine-grained, weathers yellowish orange; mostly thick to massive bedded; locally medium-scale and large-scale cross-bedded with medium-scale trough cross-beds more common toward the top of the unit.....	10.7	35.0
3. Sandstone, upper part similar to unit 4 above; base of unit is somewhat friable, slightly calcareous and contains vertical *Skolithos* burrows; beds are medium to thickly bedded containing low-angle cross-laminae; some thin interbeds of silty sandstone, poorly sorted, containing nodular and lenticular chert masses.....	21.3	70.0
Total Sandstone member.....	47.2	155.0
Dolostone member:		
2. Dolomicrite, light-gray with sparse very fine-grained quartz sand and silt; thinly bedded with samll sparry calcite nodules as much as several cm in size; some interbedded sandstone; very fine-grained to silty; friable in part; weathers very pale olive to yellowish orange. Irregular contact with sandstone above. Forms swale.....	1.8	6.0
1. Poorly exposed; zone of extrremely siliceous, mostly horizontally laminated to possible low-angle cross-bedded sandstone; fine to medium grained. Base not exposed. Estimated thickness.....	15.2	50.0
Total Dolostone member.....	17.0	56.0
Total Quadrant Sandstone.....	64.2	211.0
Heath Formation (Mississippian):.....	Not measured	

QUADRANT MOUNTAIN (10)
Type Section of the Quadrant Sandstone
Mt Holmes 15′ Quadrangle
southeast spur of Quadrant Mountain,
Yellowstone National Park, Wyoming

The Quadrant Mountain section is the type locality for the Quadrant Sandstone (Weed, 1896, p. 5; Iddings and Weed, 1899, p. 33-34) and Thompson and Scott (1941, p. 349-353). According to Ruppel (1982), "the resistant rocks [of the Quadrant Sandstone] and those of the overlying Shedhorn Sandstone form the largest of the cliff-rimmed dipslopes of the Gallatin Range; Quadrant Mountain, the slope dipping north from Bannock Peak, and many smaller, similar slopes and bedrock-controlled benches" (fig. 13). The following is a slightly annotated version of the description given by Thompson and Scott (1941).

	Thickness	
	Meters	Feet
Phosphoria Formation (Permian):		
Shedhorn Sandstone:.....	Not measured	
Quadrant Sandstone (Pennsylvanian):		
Sandstone member:		
19. Limestone, gray, brecciated.....	2.1	7.0
18. Sandstone, quartzitic.....	0.6	2.0
17. Limestone, light-gray, cherty, siliceous, with sandstone lenses; brachiopod fragments, *Wedekindellina cf. W. excentrica* (Roth and Skinner) and *Fusulina* sp.....	4.3	14.0
16. Sandstone, tan-colored, massive, saccharoidal, massive.....	4.6	15.0
15. Quartzite [silica-cemented sandstone], brown to white.....	0.6	2.0
14. Limestone [dolostone], cherty, compact.....	1.8	6.0
13. Quartzite [silica-cemented sandstone], cross-bedded, ripple marked, black on surface.....	3.4	11.0
12. Quartzite [silica-cemented sandstone], calcareous	2.4	8.0
11. Sandstone, tan-colored, cross-bedded, coarse-grained; erosional surface at base.....	1.8	6.0
10. Limestone, light gray, cherty and fossiliferous..	2.4	8.0
9. Sandstone, hard, like quartzite [silica cemented]	8.8	29.0
8. Quartzite [silica-cemented sandstone], white to brown.....	3.0	10.0
7. Limestone, gray.....	0.6	2.0
6. Quartzite [silica-cemented sandstone], gray, cross-bedded, sandy at base, calcareous at top.....	35.4	116.0
Total Sandstone member.....	71.8	236.0

	Thickness	
	Meters	Feet
Dolostone member:		
5. Limestone, dolomitic	3.0	10.0
4. Sandstone, hard [silica-cemented]	0.9	3.0
3. Limestone, gray	1.5	5.0
2. Sandstone, calcareous	1.2	4.0
1. Limestone, light gray with a two inch shale parting near base	6.4	21.0
Total Dolostone member	13.0	43.0
Total Quadrant Sandstone	84.8	279.0

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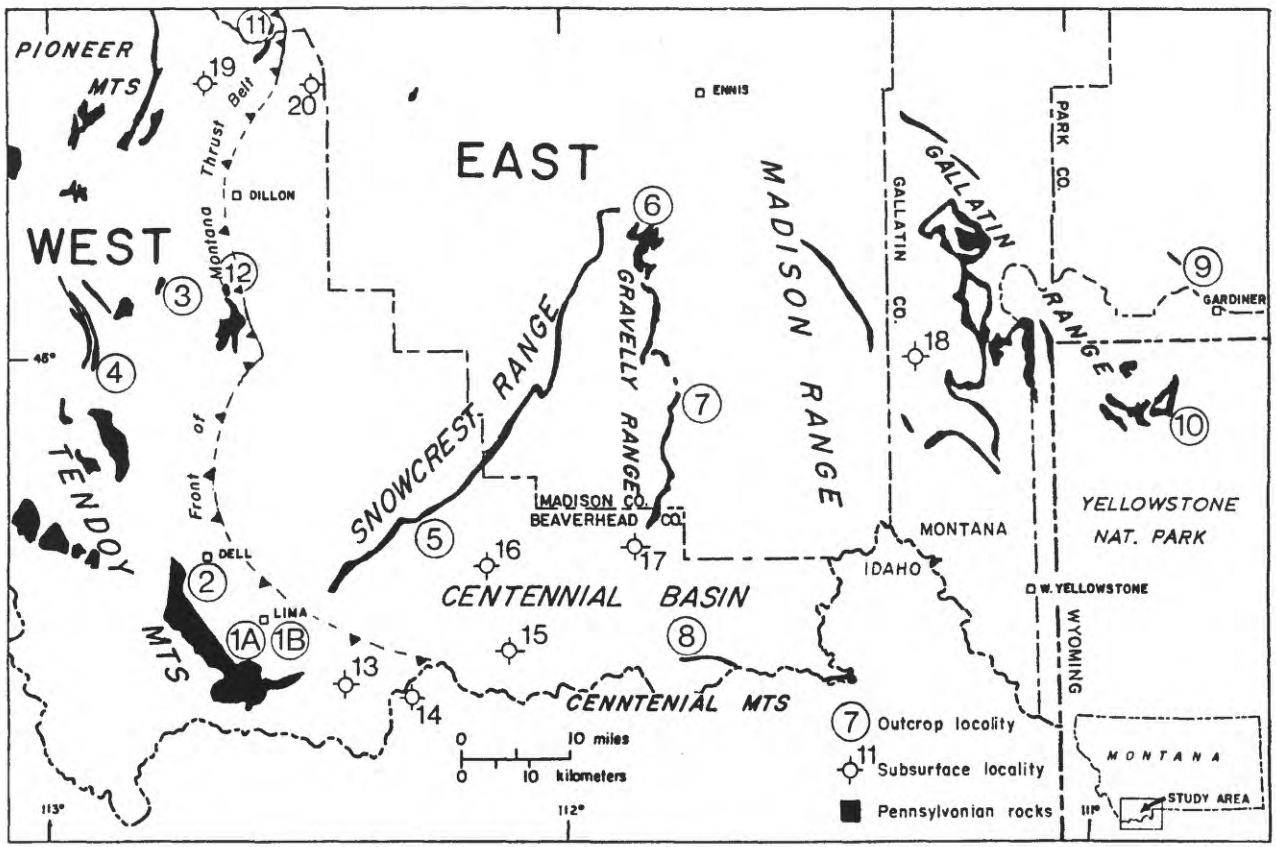

Figure 1. Locations of principal stratigraphic sections referred to in this report. See table 1 for names and locations of numbered localities and figures 4 through 13 for detail locations of outcrop sections. Distribution of Pennsylvanian rocks (undivided) taken from the Geologic Map of Montana (Ross and others, 1955).

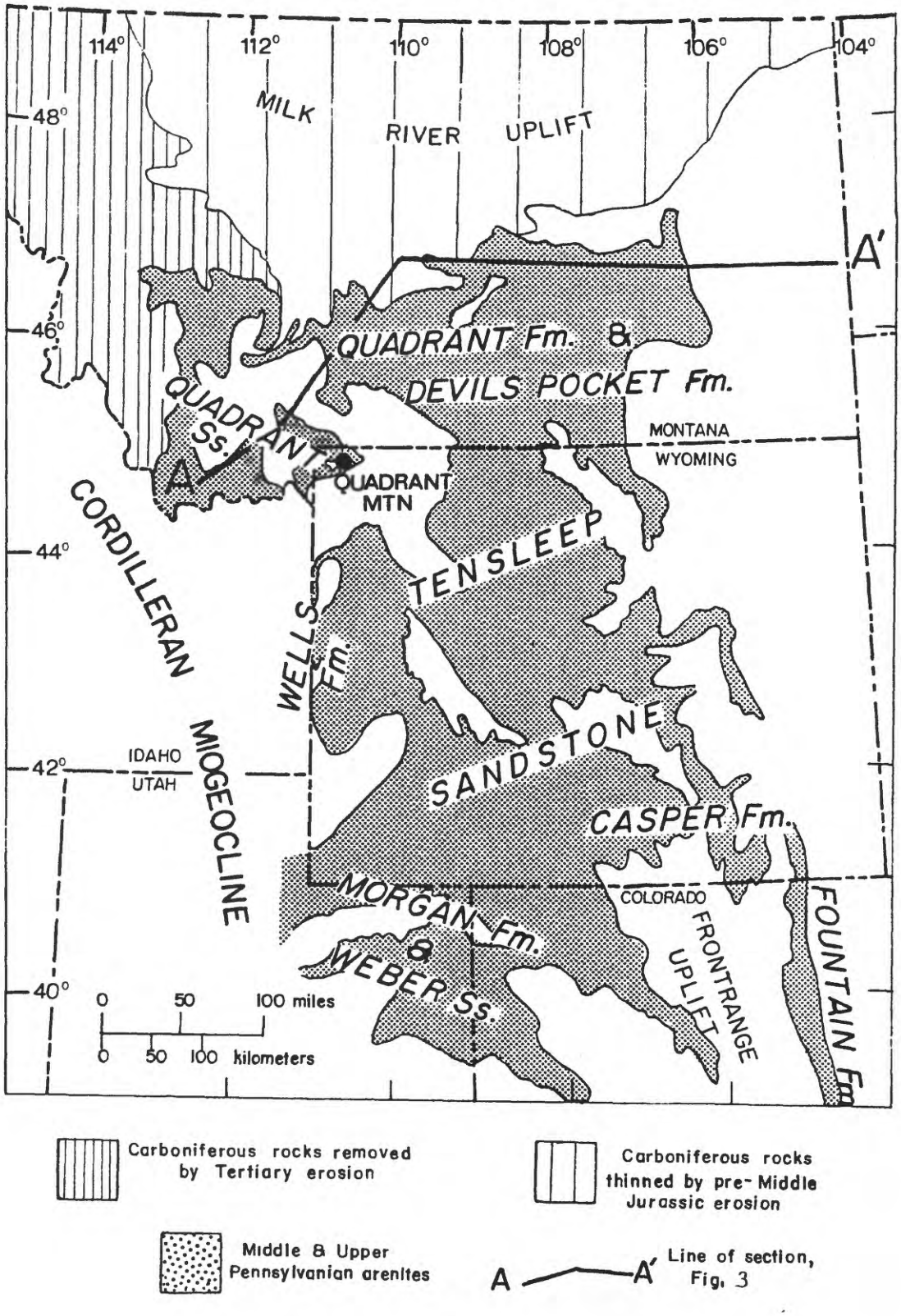

Figure 2. Mid Pennsylvanian arenites of the Rocky Mountain Paleozoic cratonic platform (modified from Mallory, 1972).

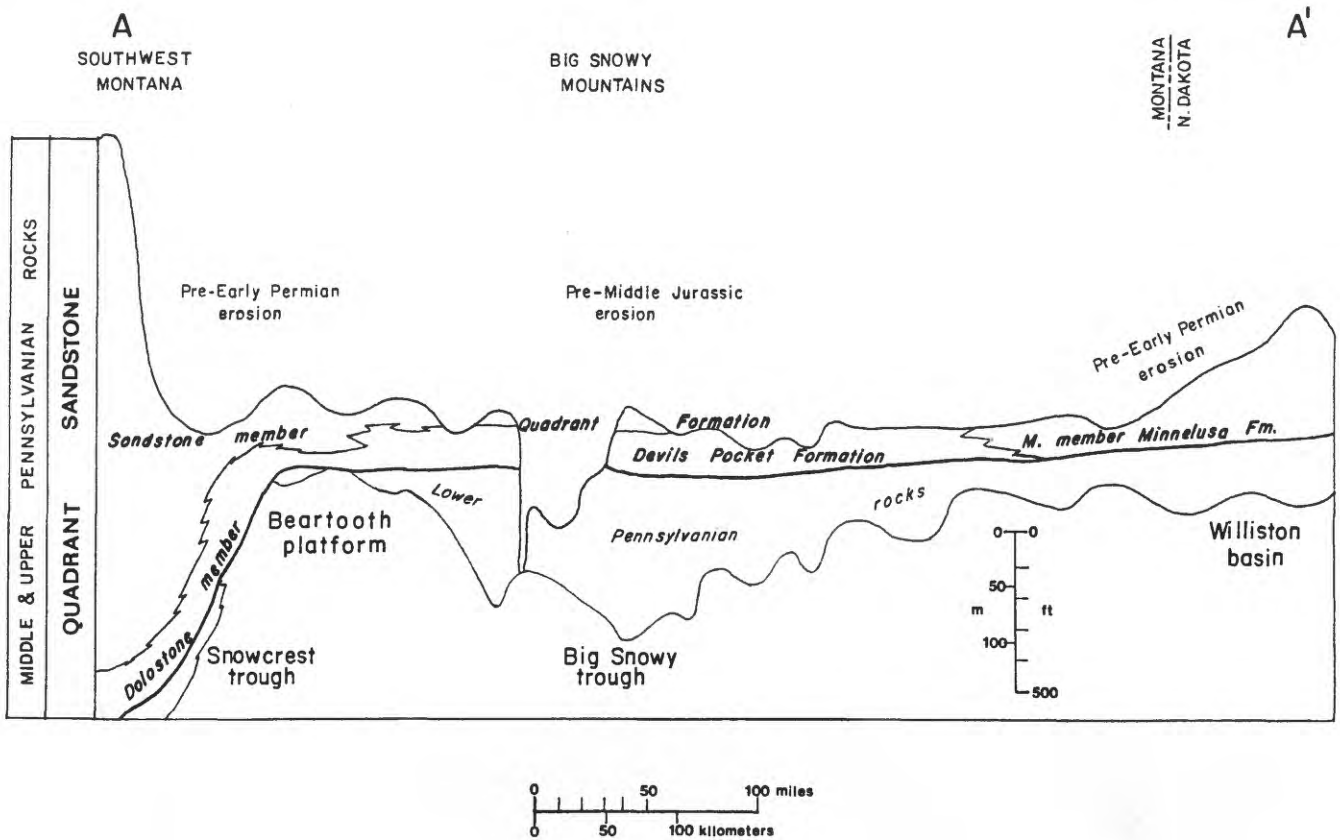

Figure 3. Generalized cross section demonstrating regional stratigraphy of the Quadrant Sandstone and equivalent strata across Montana. Vertical scale is highly exaggerated (modified from McKee and others, 1975).

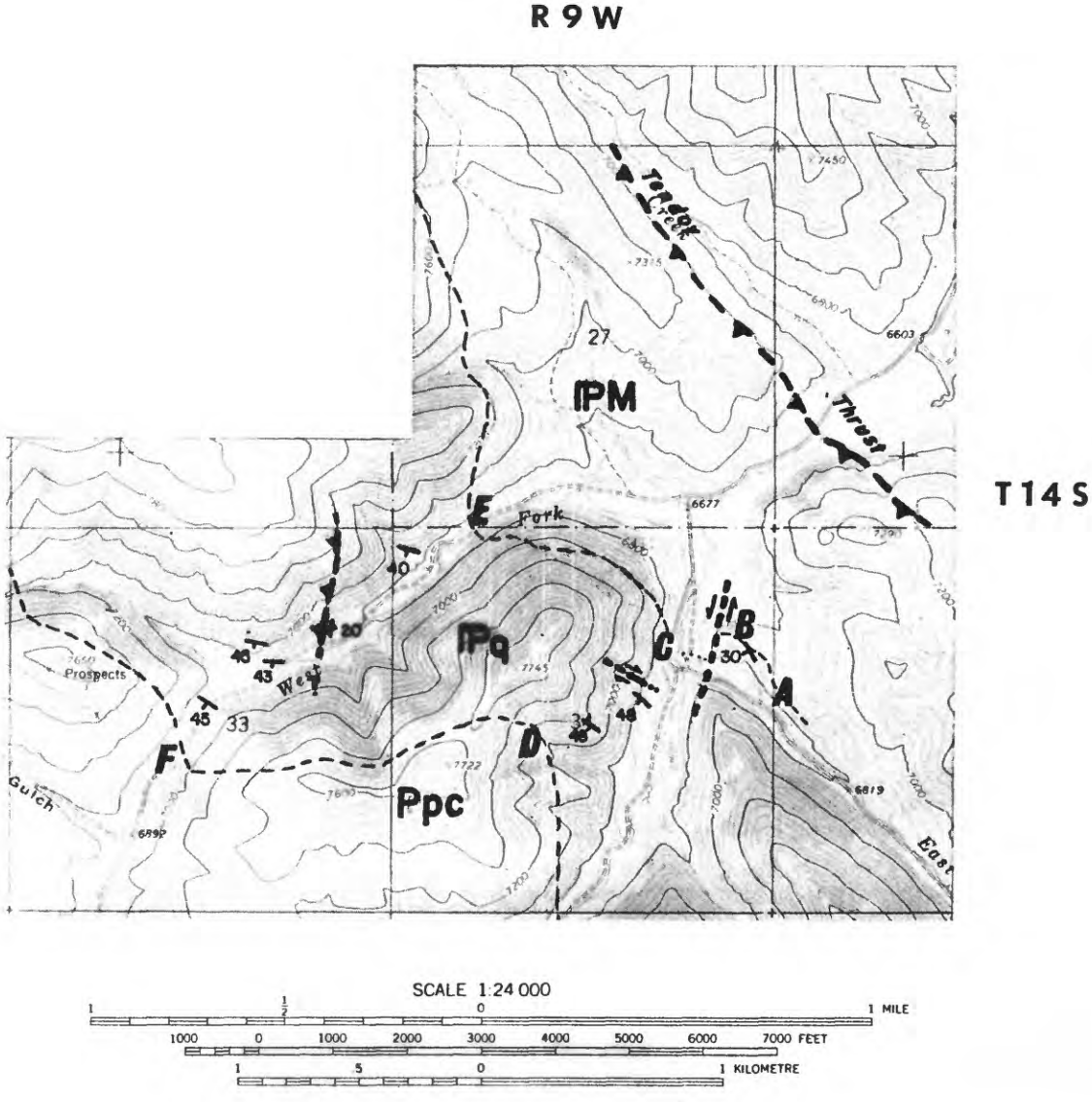

Figure 4. Geologic map of the Little Sheep Creek area showing locations of measured sections of the Quadrant Sandstone. Section traverses are represented by A, base of section; D, top of section for Middle Fork of Little Sheep Creek (loc. 1A); and E, base of section; F, top of section for West Fork, Little Sheep Creek (loc. 1B). Ppc= Permian Park City Formation; see table 2 for complete explanation of map symbols. Geology modified from Sadler (1980) and from unpublished data by W. J. Perry Jr., (personal communication). Topographic base map from U.S. Geological Survey Gallagher Gulch quadrangle map, Beaverhead County (7 $\frac{1}{2}$ min. series).

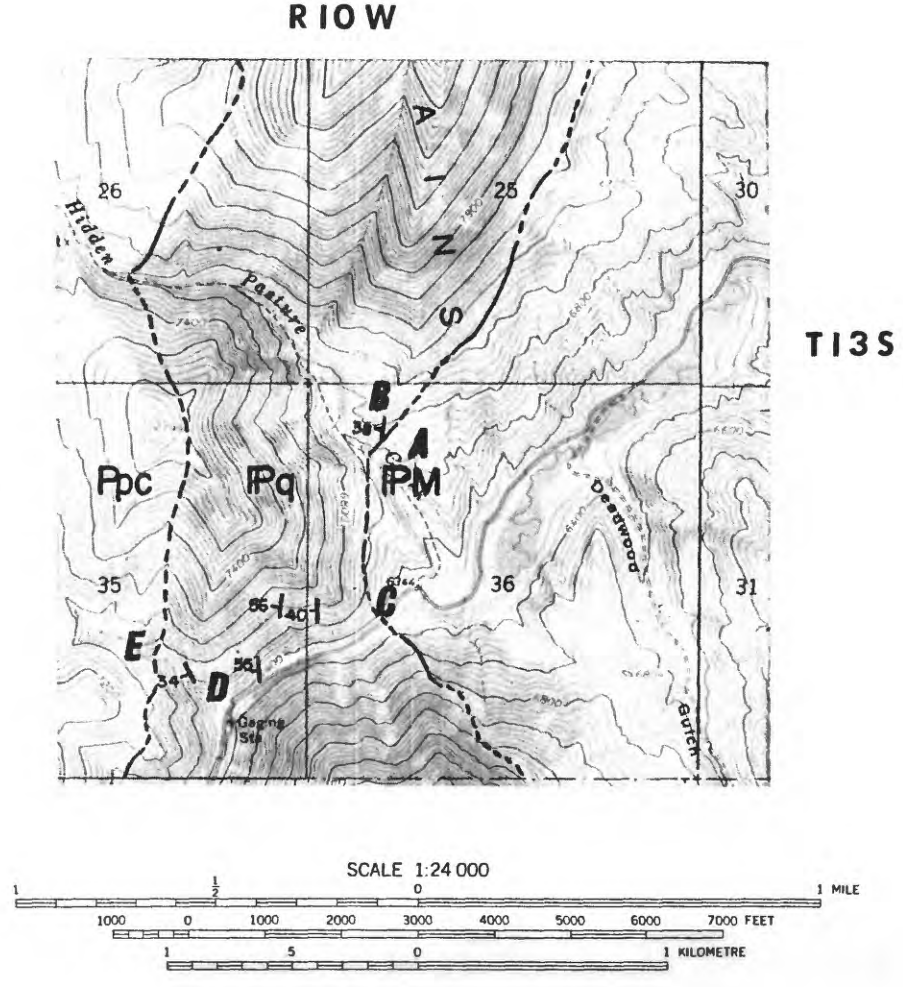

Figure 5. Geologic map of the Hidden Pasture-Big Sheep Creek area showing location of composite measured section of the Quadrant Sandstone. Section traverse (offset twice) is represented by A, base of section; E, top of section. Ppc= Permian Park City Formation. Geology modified from Klecker (1981). Topographic base map from U.S. Geological Survey Dixon Mountain quadrangle map, Beaverhead County (7 1/2 min. series).

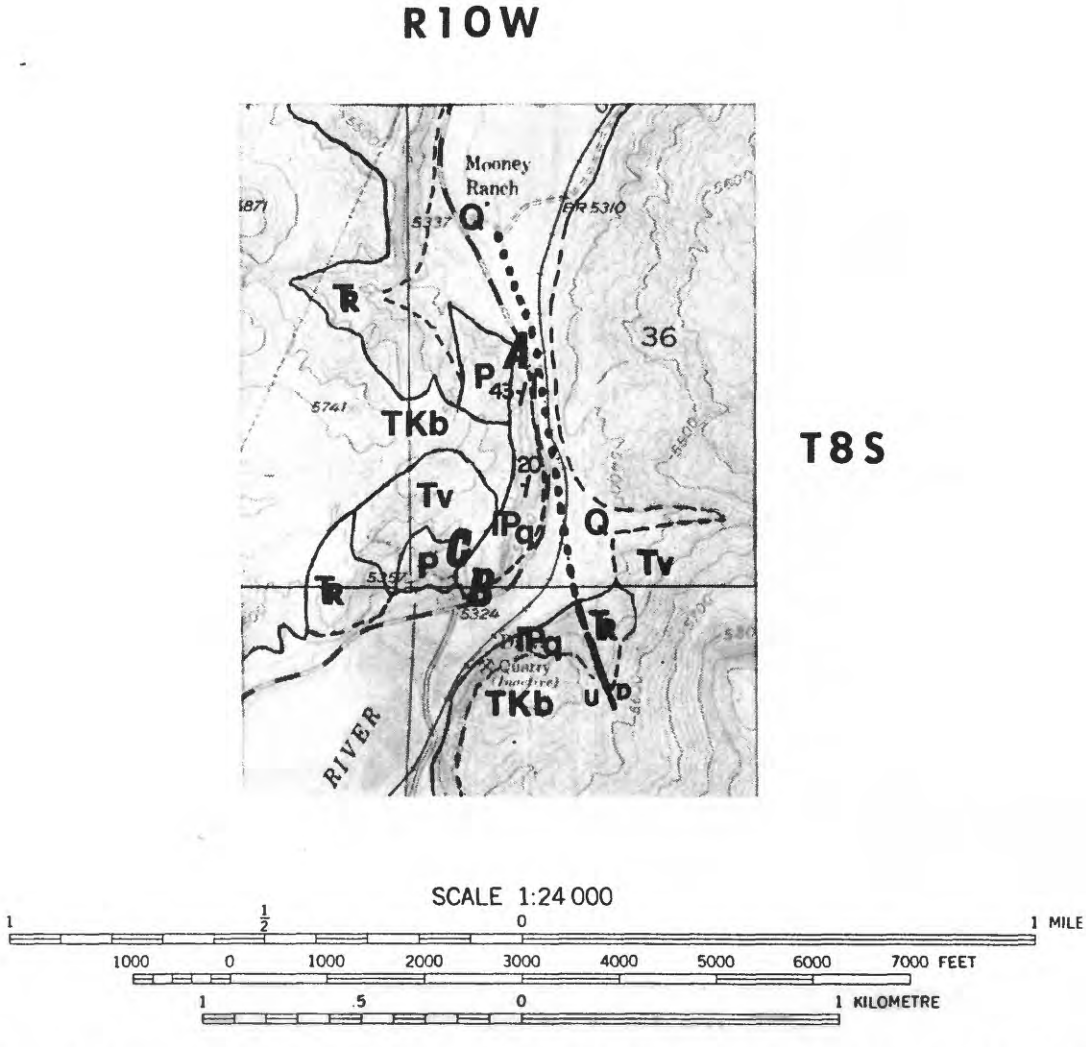

Figure 6. Geologic map of the Dalys Spur area showing location of measured section of the upper part of the Quadrant Sandstone. Section traverse is represented by A, base of section measurement; D, top of section. Geology taken from Lowell (1965). Topographic base map from U.S. Geological Survey Dalys quadrangle map, Beaverhead County (7 1/2 min. series).

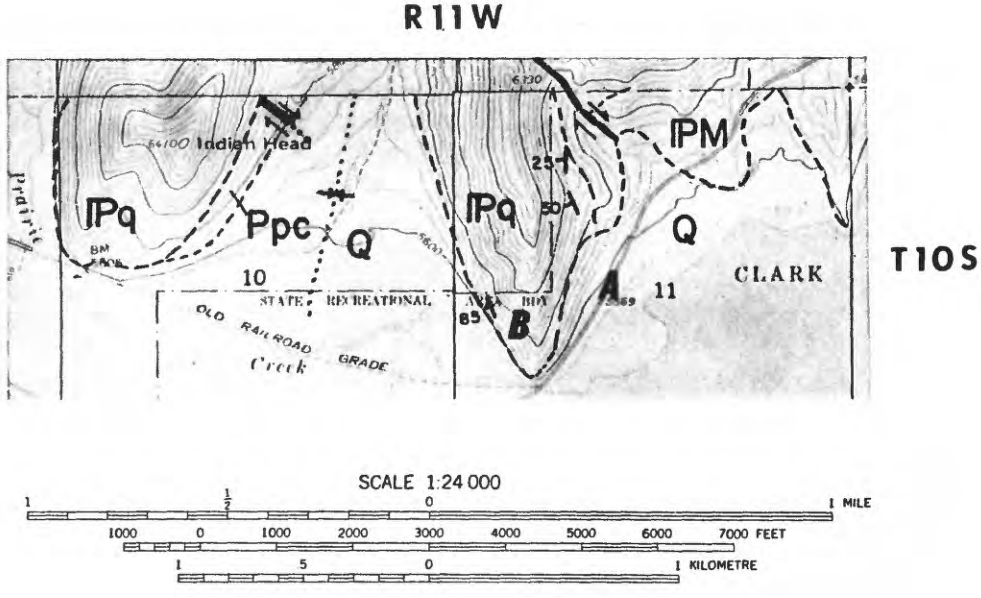

Figure 7. Geologic map of the Armstead area showing location of measured section of the Quadrant Sandstone. Section traverse is represented by A, base of section and B, top of section. Ppc= Permian Park City Formation. Geology modified from Lowell (1965). Topographic base map from U.S. Geolgical Survey Garfield Canyon quadrangle map, Beaverhead County (7 1/2 min. series).

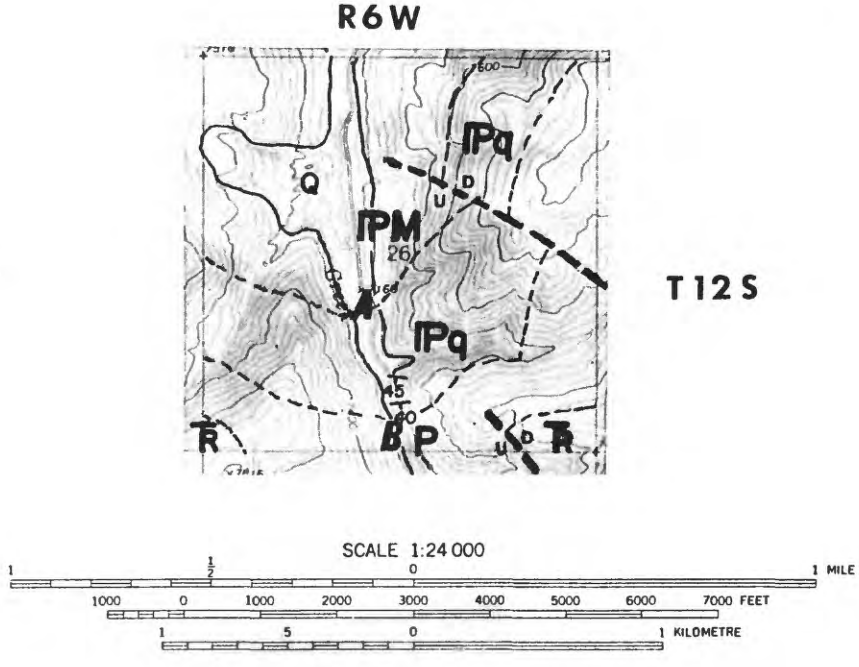

Figure 8. Geologic map of the Clover Divide area showing location of measured section of the Quadrant Sandstone. Section traverse is represented by A, base of section; B, top of section. Geology modified from Zeigler (1954). Topographic base map from U.S. Geological Survey Whiskey Spring quadrangle map, Beaverhead County (7 1/2 min. series).

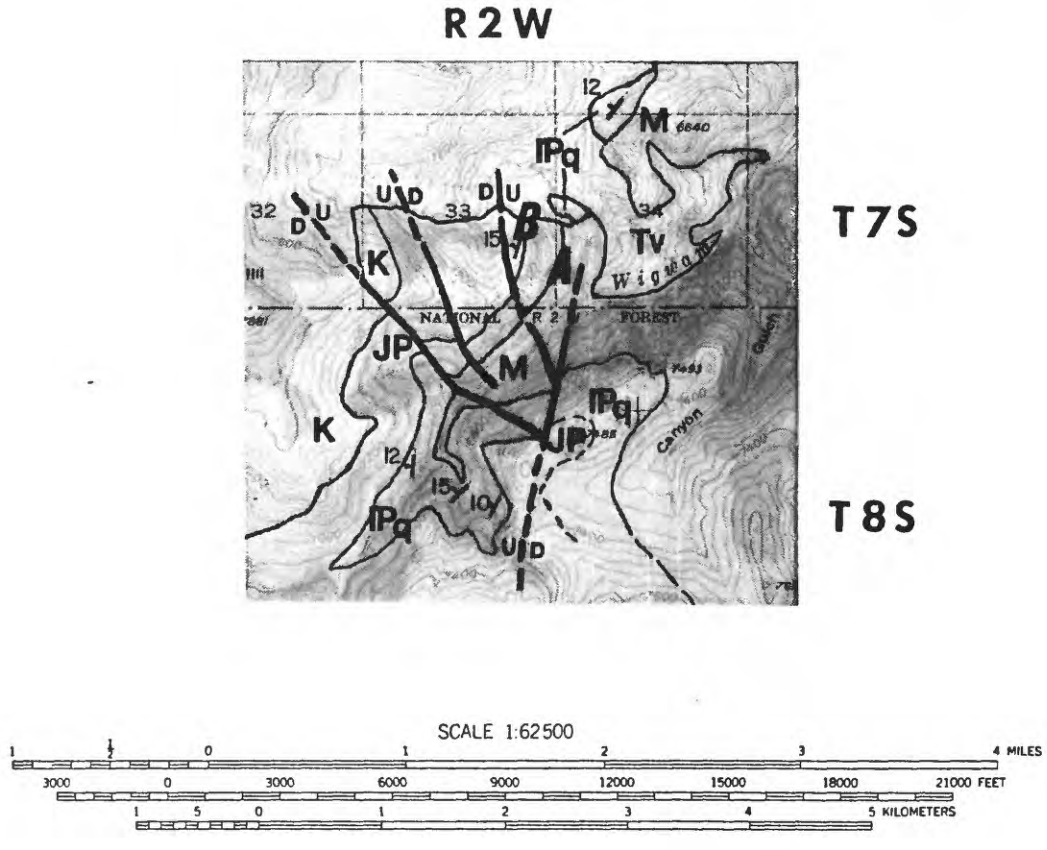

Figure 9. Geologic map of the Wigwam Creek area showing location of measured section of the Quadrant Sandstone. Section traverse is represented by A, base of section; B, top of section. JP= Jurassic through Permian strata. Geology from Hadley (1969). Topographic base map from U.S. Geological Survey Varney quadrangle map, Madison County (15 min. series).

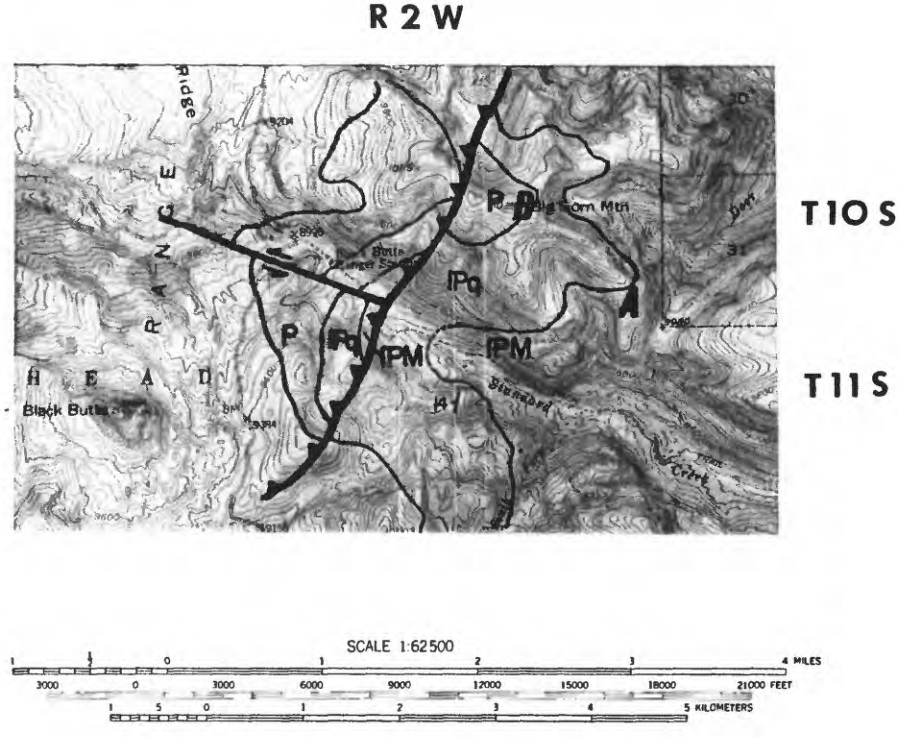

Figure 10. Geological map of the Big Horn-Black Butte area showing locations of composite measured section of the Quadrant Sandstone. Section traverse at Big Horn Mountain is represented by A, base of section; B, top of section. Geology modified from Mann (1954). Topographic base map from U.S. Geological Survey Monument Ridge quadrangle map, Madison County (15 min. series).

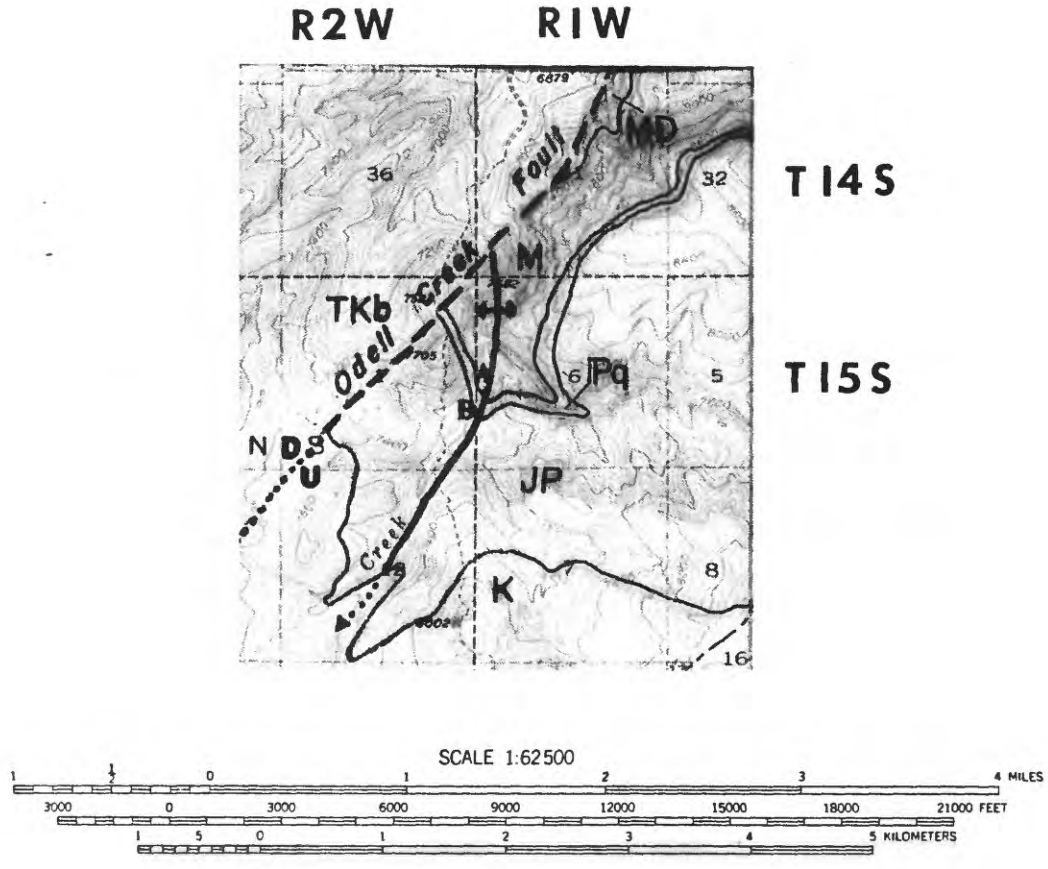

Figure 11. Geological map of the Odell Creek area showing location of measured section of the Quadrant Sandstone. Section traverse is represented by A, base of section; B, top of section. JP= Jurassic through Permian strata; MD= Mississippian through Devonian strata. Geology modified from Witkind and Prostka (1980). Topographic base map from U.S. Geological Survey Lower Red Rock Lake quadrangle map, Beaverhead County (7 1/2 min. series).

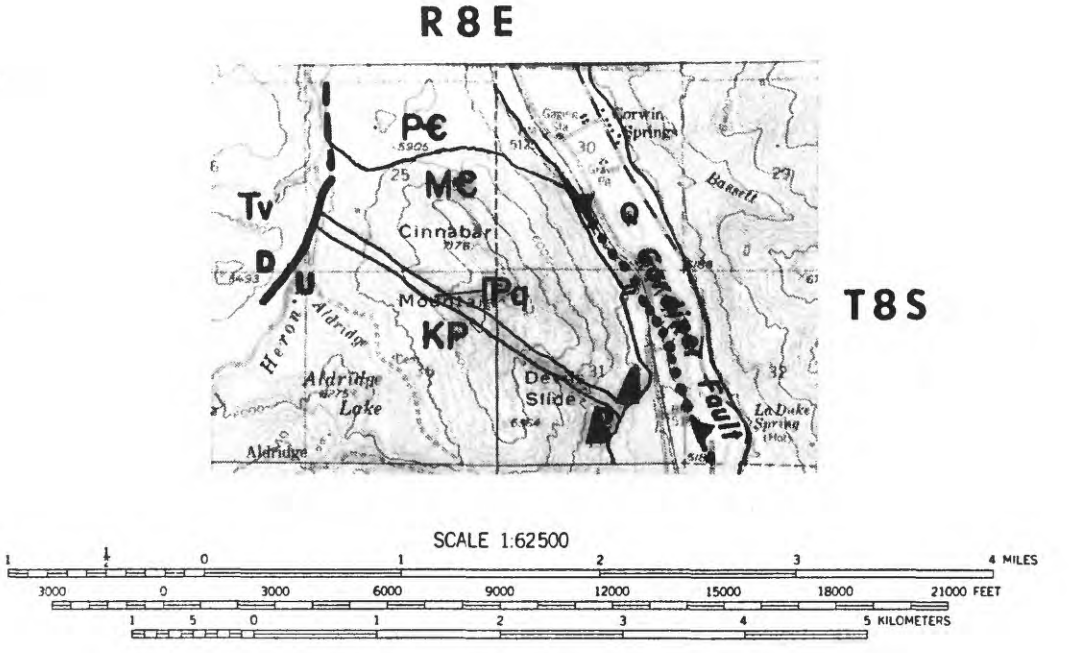

Figure 12. Geologic map of the Cinnabar Mountain area showing location of measured section of the Quadrant Sandstone. Section traverse is represented by A, base of seciton and B, top of section. MC= Mississippian through Cambrian strata. Geology taken from Calvert (1912) and from Roberts (1972). Topographic base map from U.S. Geological Survey Miner quadrangle map, Park County (15 min. series).

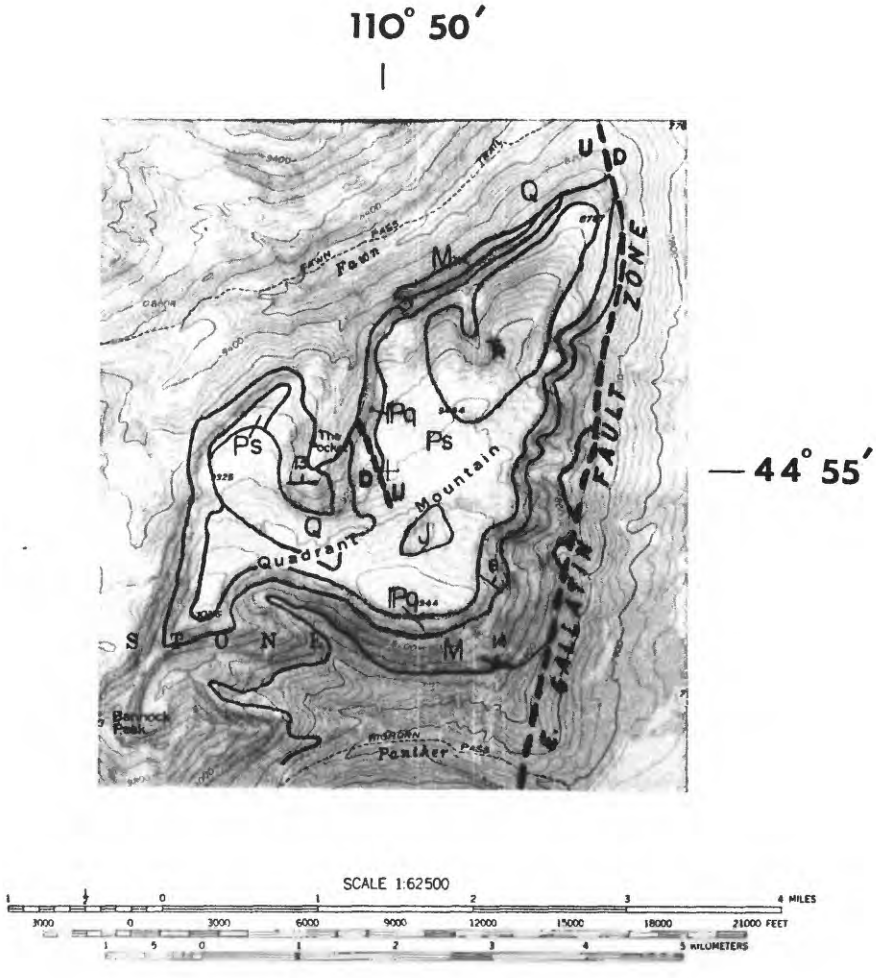

Figure 13. Geologic map of the Quadrant Mountain area showing general vicinity in which previous workers have measured the type section of the Quadrant Sandstone. Ps= Permian Shedhorn Sandstone. Geology taken from Ruppel (1972). Topographic base map from U.S. Geological Survey Mount Holmes quadrangle map, Yellowstone National Park, Wyoming (15 min. series).

Table 1. Index to localities shown in figure 1

Table 1

Locality No.	Name	Township and Range	County
1A.....	Middle Fork, Little Sheep Creek.....	NE 1/4 and N 1/2 sec. 34, T. 14 S., R. 9 W.....	Beaverhead
1B.....	West Fork, Little Sheep Creek.....	SW 1/4 sec. 27 and NE 1/4 sec. 33, T. 14 S., R. 9 W.....	Do.
2.....	Hidden Pasture Trail-Big Sheep Creek...	SE 1/4 sec. 35 and NW 1/4 sec. 36, T. 13 S., R. 10 W.....	Do.
3.....	Dalys Spur.....	SW 1/4 sec. 36, T. 8 S., R. 10 W.....	Do.
4.....	Armstead.....	SW 1/4 sec. 11, T. 10 S., R. 11 W.....	Do.
5.....	Clover Divide.....	S 1/2 sec. 26, T. 12 S., R. 6 W.....	Do.
6.....	Wigwam Creek.....	SW 1/4 sec. 34, and SE 1/4 sec. 33, T. 7 S., R. 2 W.....	Madison
7.....	Black Butte-Big Horn Mountain.....	NE 1/4 sec. 2, T.11 S., R. 2 W. and NW 1/4 sec. 36, T. 10 S., R. 2 W.	Do.
8.....	Odell Creek.....	SE 1/4 sec. 1, T. 15 S., R. 2 W. and SW 1/4 sec. 6, T. 15 S., R. 1 W.	Beaverhead
9.....	Cinnabar Mountain.....	SE 1/4 NW 1/4 sec. 31, T. 8 S., R. 8 E.....	Park
10.....	Quadrant Mountain.....	located near 45° 55′ N. latitude, 110° 50′ W. longitude.....	Yellowstone N.P., Wyoming

Table 2. Explanation of geologic map symbols

Table 2

Q Quaternary colluvium, alluvium and glacial deposits undivided	
Tv Tertiary volcanics, undivided	Contact-Dashed where approximately located
TKb Tertiary and Upper Cretaceous Beaverhead Formation	
K Cretaceous rocks undivided	Fault-dashed where approximately located; dotted where concealed
J Jurassic rocks undivided	D / U Normal Fault- (D) on downthrown side; (U) on upthrown side
TR Triassic rocks undivided	Thrust Fault-Sawteeth on upper plate
P Permain Phosphoria Formation	
PPq Pennsylvanian Quadrant Sandstone	Anticline
PPM Pennsylvanian and Mississippian rocks undivided (includes Amsden Formation, Big Snowy Group and Madison Limestone)	Syncline
M Mississippian Madison Limestone	22 Strike and dip of beds
PC Precambrian crystalline rocks undivided	