DEPARTMENT OF THE INTERIOR

U. S. GEOLOGICAL SURVEY

CRITICAL DEEP DRILLHOLES AND INDICATED PALEOZOIC PALEOTECTONIC FEATURES NORTH OF THE SNAKE RIVER DOWNWARP IN SOUTHERN BEAVERHEAD COUNTY, MONTANA, AND ADJACENT IDAHO

BY

WILLIAM J. PERRY, JR.[1]

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[1]MS 940, Federal Center
Box 25046
Denver, CO 80225

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INTRODUCTION

This report summarizes stratigraphic records of and upper Paleozoic paleotectonic interpretations derived from four deep drillholes north of the Snake River plain in southwestern Montana and adjacent east-central Idaho (fig. 1 and tables 1-4). These paleotectonic interpretations are compared and contrasted with those of previous workers. A generalized upper Paleozoic palinspastic reconstruction of the area of the four deep drillholes is also provided.

The drillholes are: Shell Oil Corp. no. 34x-13 Unit, in Beaverhead County, Montana (table 1); American Quasar Petroleum Co. no. 29-1 Peet Creek-Federal, in Beaverhead County, Montana (table 2); Exxon Co. no. 1 Myers-Federal, Clark County, Idaho (table 3), and Amoco Production Co. no. 1 Snowline Grazing-Federal, Beaverhead County, Montana (table 4), respectively drillholes 1 to 4, figure 1. The three drillholes in southern Beaverhead County, Montana, are near the Exxon hole in Clark County, Idaho, which is several hundred meters from the Idaho-Montana border (fig. 1). All four drillholes were rank wildcat exploratory tests for oil and gas. None of the four yielded commercial quantities of hydrocarbons, although both the Amoco and Exxon tests yielded natural gas from carbonate rocks of the Mississippian Madison Group.

The region (fig. 1) has undergone at least five episodes of deformation: (1) late Paleozoic epeirogeny and possible growth faulting associated with the development of the Snowcrest trough, (2) early Late Cretaceous development of the superposed Laramide-style Blacktail-Snowcrest uplift, (3) later Late Cretaceous to early Tertiary thin-skinned thrusting along the eastern margin of the Cordilleran thrust belt, (4) Eocene(?) to Miocene basin-and-range normal faulting associated with crustal extension, and (5) late Tertiary to Recent normal faulting associated with the development of the Snake River downwarp beneath the Snake River plain.

Tectonics of the region were discussed by Scholten and others (1955), Scholten (1967), Ryder and Scholten (1973), Skipp and Hait (1977), Witkind (1977), Perry and others (1981, 1983), and Ruppel and Lopez (1984). New interpretations of the tectonic history of this region have been developed in the last decade and are still being refined. However, much useful data and interpretations were presented in the older literature, including the concept of the Blacktail-Snowcrest "arch" (Scholten, 1967, and fig. 1, present report), a concept first proposed by Eardley (1960). Because Tertiary to Quaternary extension faults and associated basins have almost completely dismembered the Blacktail-Snowcrest arch, it only becomes a recognizable feature by backstripping, i. e., by conceptually removing the Eocene and younger cover. This feature has been more recently termed Blacktail-Snowcrest uplift by Perry and others (1981, 1983) to emphasize its similarity to other Laramide-style (thick-skin) thrust-bounded uplifts of the Rocky Mountain foreland province. Nichols and others (1985) showed by palynostratigraphic methods that this uplift was actively growing from Coniacian to mid-Campanian (Late Cretaceous) time, 88 to 78 mybp, whereas Eardley (1960) considered it a Paleocene feature.

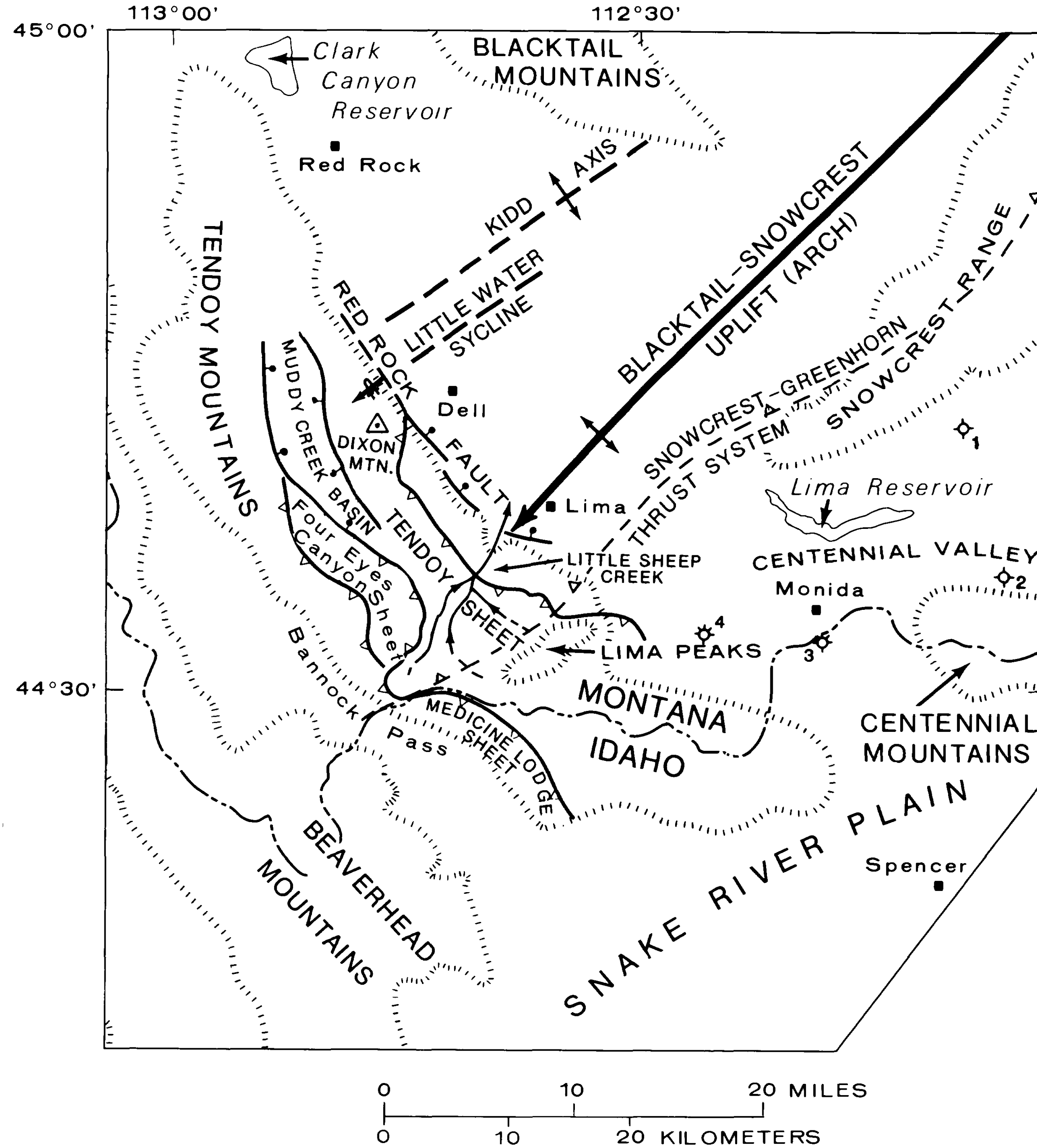

Figure 1. Index map of Lima, Montana, region, showing major physiographic and structural features and locations of drillholes; map modified from Perry and Sando (1983). Position of the Kidd "anticlinal axis" and Little Water synclinal axis are from Scholten and others (1955). Trend-line of the "Blacktail-Snowcrest arch" is from Scholten (1967); both this and the Kidd "axis" probably never represented true anticlinal axes. Both features appear to be closely similar in style to the Wind River uplift of Wyoming. The term uplift (i. e., Perry and others, 1981, 1983) is used in the present report to emphasize the similarity of the Blacktail-Snowcrest massif to other Laramide uplifts of the Rocky Mountain foreland. Drillholes 1 through 4 are described in Tables 1 through 4.

Basic data used in the preparation of this report included suites of geophysical borehole logs from each of the four drillholes and lithologic logs (based on well cuttings) prepared by American Stratigraphic Company[1] for drillholes 1, 2, and 3. In addition, I examined well cuttings from critical intervals in all four drillholes. I thank the respective operators (Shell Oil Corporation, American Quasar Petroleum Company, Exxon Company, USA, and Amoco Production Company) for the opportunity to examine suites of cuttings from each of the drillholes.

Background information used for recognizing the stratigraphic units listed in Tables 1 through 4 (drillhole stratigraphic correlations) was obtained from reports by McKelvey (1959), Sandberg and Mapel (1967), Sando and others (1975), Witkind (1977), Hadley (1980), Saperstone and Ethridge (1984), and Wardlaw and Pecora (1985) and from an unpublished Masters thesis by Moran (1971). Upper Paleozoic stratigraphy of the Blacktail and Snowcrest Ranges north of the drillholes was elucidated by Klepper (1950), Gealy (1953), Zeigler (1954), Scholten and others (1955), and Pecora (1981), as well as by the general references listed above for the drillhole correlations. W. J. Sando and J. T. Dutro, in Hadley (1980), provided a most useful discussion of stratigraphic relationships in the northern Gravelly and Greenhorn Ranges northeast of the drillholes. Descriptions of the Triassic sequence south of the Snake River plain by High and Picard (1967, 1969) and Froidevoux (1977, p. 569-572) were particularly useful for recognizing Triassic units in the four drillholes, because the Triassic stratigraphy north and south of the Snake River plain is closely comparable. In contrast, the Jurassic sequence and much of the Paleozoic sequence change across the plain. Many of the paleotectonic implications of the well data presented in this report were first proposed by Maughan and Perry (1982), foreshadowed by the astute observations of McMannis (1965, p. 1809 and fig. 6). Peterson (1985) provided a regional summary of paleotectonic features in Montana and adjacent areas, which incorporated data from the wells summarized in this report.

This report has benefited from my many discussions of the subsurface data with T. S. Dyman, E. A. Maughan, C. A. Sandberg, W. J. Sando, and H. I. Saperstone, as well as from my discussions with geologists in the petroleum industry, many of whom either were present during drilling or developed the drilling prospects. This brief report has benefited from careful reviews by A. E. Merewether and C. A. Sandberg.

DISCUSSION

The stratigraphic data from the four drillholes (fig. 1 and tables 1-4) and from surface investigations north and east of the drillholes indicate that a profound change in upper Paleozoic stratigraphy, particularly in the thicknesses of potential oil and gas source and reservoir rocks, takes place south of or beneath the Laramide Snowcrest-Greenhorn thrust system of Perry and others (1983; Greenhorn lineament of Maughan, 1983) and north of drillhole 1 (fig. 1). Very thick upper Paleozoic stratigraphic units, which define the Snowcrest trough north of the Snowcrest-Greenhorn system, occur just north of thin to absent correlative sequences of the adjacent late Paleozoic Wyoming shelf encountered in the four drillholes (figs. 2 and 3 and table 5). These relations mandate a substantially different interpretation of the region from

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[1]Any use of corporate or trade names in this report is for purposes of acknowledgement and does not imply endorsement by the U. S. Geological Survey.

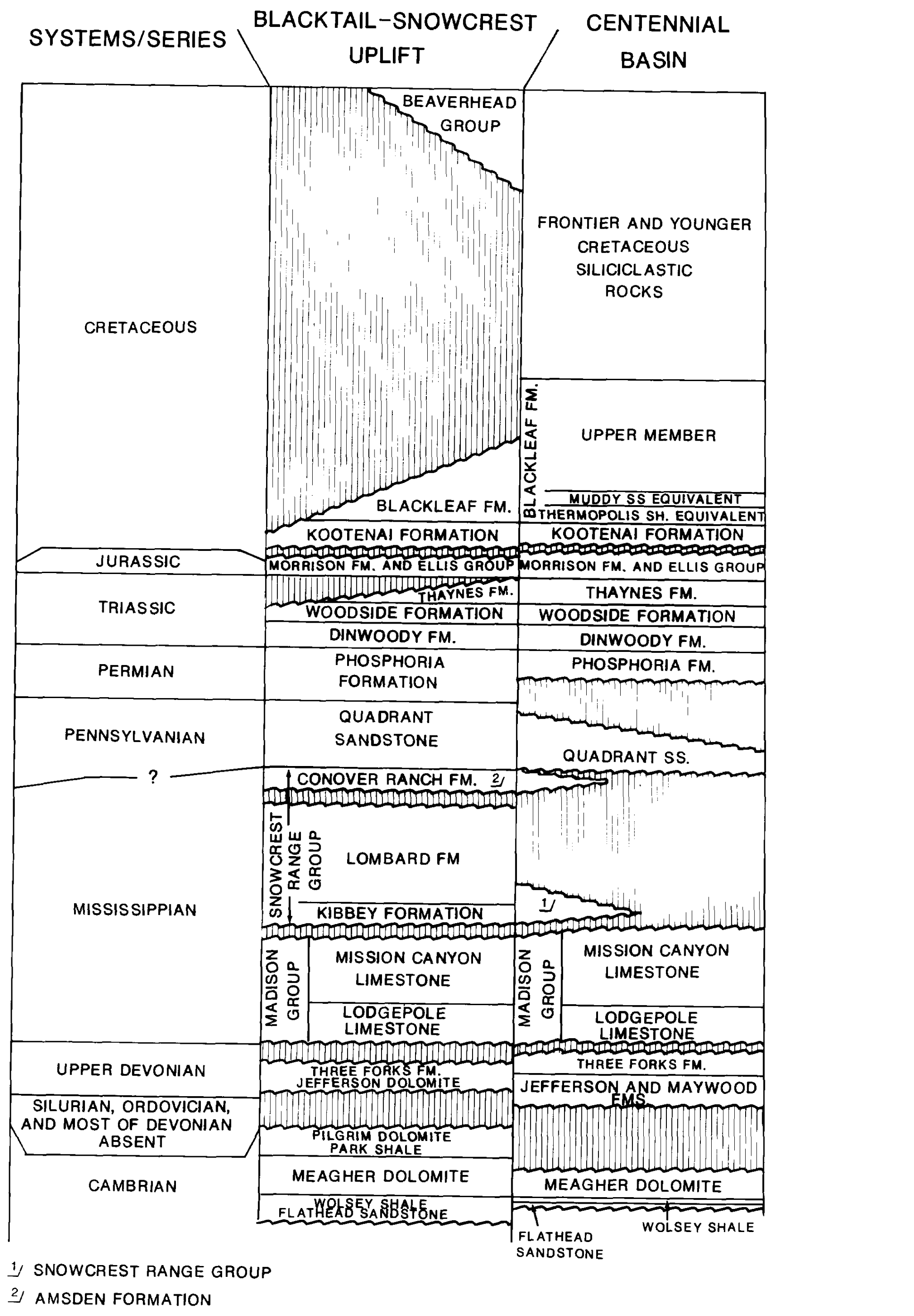

Figure 2. Correlation chart for Paleozoic and Mesozic rocks of the Blacktail-Snowcrest uplift and adjacent Centennial basin. Stratigraphic sequence of the Tendoy thrust sheet is that of the middle column, although beds older than upper Lombard Formation are not exposed on the Tendoy sheet. Lined pattern represents a hiatus in the stratigraphic sequence. Wardlaw and Pecora (1985) formalized the usage of Kibbey and Lombard as formations in southwest Montana in place of Big Snowy Formation and introduced the name Conover Ranch Formation for beds previously known as Amsden Formation. They defined Snowcrest Range Group to encompass all three new formations.

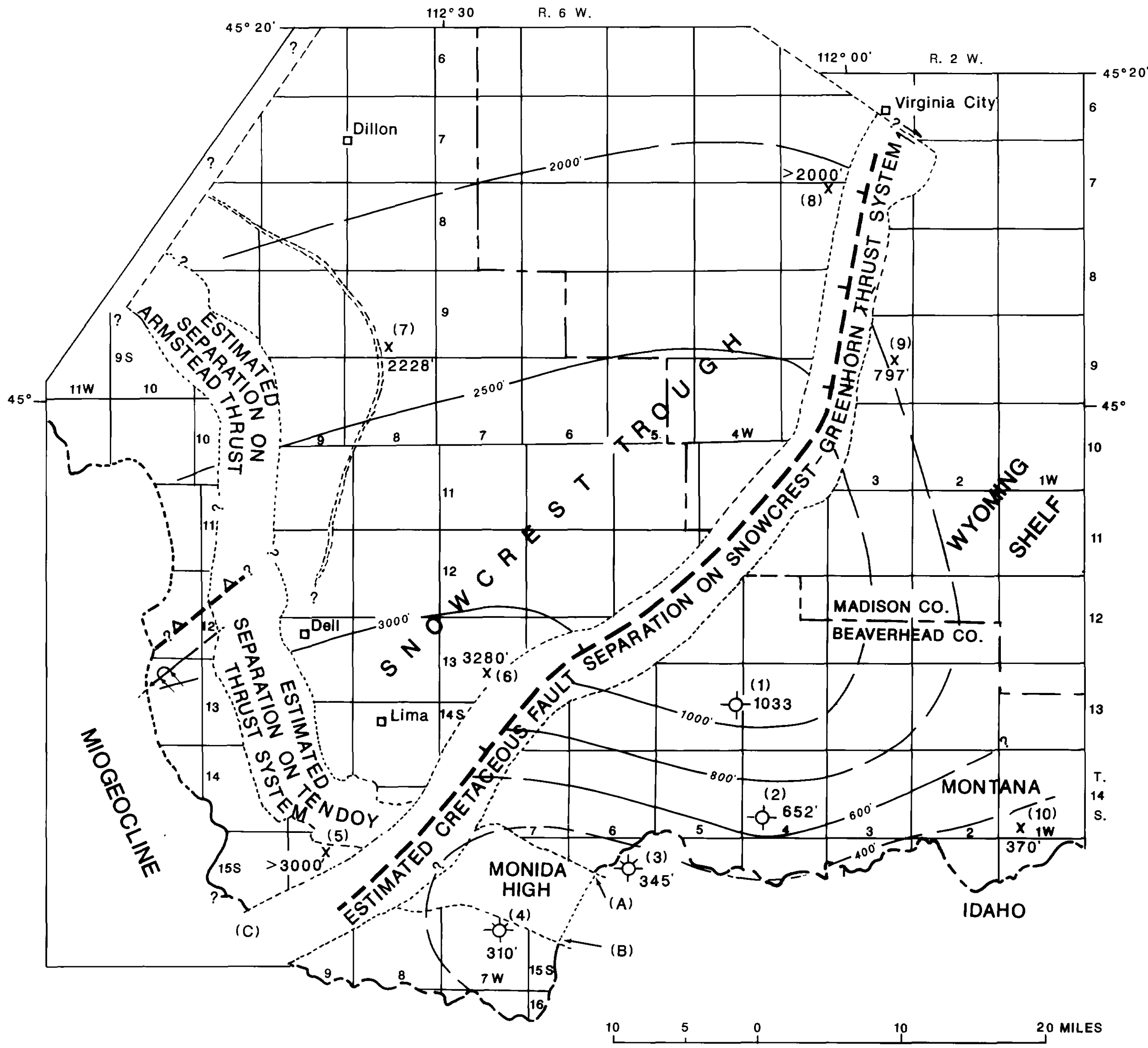

Figure 3. Isopachous map of Upper Mississippian through Permian formations and Paleozoic tectonic features. Generalized palinspastic base map constructed to remove effects of post-Paleozoic deformation. Drillholes 1 through 4 are described in Tables 1 through 4. Numbered surface thicknesses are from the following sources: (5) estimated by the author from unpublished section of upper Snowcrest Range Group measured by E. K. Maughan, sections of Quadrant Sandstone measured by Saperstone (1986a), and Permian thicknesses from McKelvey (1959); (6) from Zeigler (1954); (7) from Pecora (1981); (8) and (9) from Hadley (1980), and (10) from Moran (1971). Letters in parentheses are as follows: Distance (A) to (B) is the estimated cumulative fault separation on the Lima thrust system; (B) is the hanging wall cutoff of Paleozoic rocks. The region west and northwest of (C) represents the unknown separation between Tendoy, Medicine Lodge and Four Eyes Canyon thrust sheets. Thickness contour interval variable.

that of Peterson (1981), in that the thin upper Paleozoic formations in the southern part of the area ('Monida high' of Saperstone, 1986b, fig. 52; fig. 3) are incompatible with Peterson's "Snake River downwarp". His interpretation of a downwarp was based on the presence of thick Mississippian and younger Paleozoic formations in the southern part of the Medicine Lodge thrust sheet (fig. 1 and area (C), fig. 3), which were displaced eastward from the Paleozoic miogeocline during Late Cretaceous time (Perry and Sando, 1983) as a result of Sevier-style thrusting. The interpretation of a downwarp was later abandoned by Peterson (1985). Stratigraphic data from Moran (1971) indicate a very thin upper Paleozoic sequence in the eastern Centennial Mountains: Permian Phosphoria Formation, 200 ft (61 m) thick; Pennsylvanian Quadrant Sandstone, 90 ft (27 m) thick, and Mississippian to Pennsylvanian Amsden Formation, 80 ft (24 m) thick. This very thin upper Paleozoic sequence is comparable to that of the Monida high represented by the Exxon and Amoco drillholes (3 and 4, fig. 3; tables 3 and 4), which encountered a drilled thickness of respectively 355 ft (108 m) and 310 ft (94 m) of upper Paleozoic rocks. This area of thin upper Paleozoic rocks, which apparently extends from the Monida high eastward through the Centennial Mountains, was an area of intermittent nonsubsidence and erosion during Cambrian through Permian time. This large positive feature was interpreted from studies of Devonian rocks and named the Yellowstone Park uplift by Sandberg and Mapel (1967). Peterson (1985) determined that the positive feature was present during the late Paleozoic and modified the name to "Yellowstone high". The northwestern edge of this high coincides with the southeastern boundary of figure 3. The eastern part of Peterson's "Yellowstone high" coincides with the "Southern Montana arch" of Sando and others (1975, figs. 18 and 19), recognized on the basis of thin Late Mississippian (Chesterian) strata. The present report concludes that the "Southern Montana arch" extended as far west as Monida during Late Mississippian time.

In contrast to the thin upper Paleozoic formations of the Yellowstone high, which includes the Monida high and Southern Montana arch, the upper Paleozoic rocks of the adjacent Snowcrest trough are locally more than 3,000 ft (1 km) thick (figs. 2 and 3). The formations are thickest along the southeastern margin of the trough, suggesting that they were deposited on the northeast side of a down-to-the-north normal fault system. Therefore the Snowcrest trough may be a Paleozoic half-graben. The inferred bounding normal fault(s) were either obscured by subsequent deformation or reactivated as the Snowcrest-Greenhorn thrust system. Measured sections of the Upper Mississippian Kibbey and Lombard ("Big Snowy") Formations by Byrne (1985), made available to the writer after the preparation of this report, suggest that thickness estimates of Upper Mississippian rocks in the southwestern Snowcrest Range by Zeigler (1954) are excessive. I used these thickness estimates together with Pennsylvanian Quadrant Sandstone thickness estimates by Klepper (1950) and Permian measured sections described by McKelvey (1959) to estimate the total thickness of post-Madison late Paleozoic rocks at locality 6 (fig. 3). The thickness of post-Madison late Paleozoic rocks at this locality therefore probably does not exceed 3000 ft (914 m) but is close to that thickness.

The Cretaceous displacement on the Snowcrest-Greenhorn thrust system shown on the palinspastic map (fig. 3) is based on recent gravity modelling (Kulik and Perry, in prep.) and is speculative. This estimated fault separation (fig. 3) of 4 to 5 miles (6.4 to 8 km) is less than that estimated by Kulik (1982), Perry and Kulik (1983), and Perry and others (1983). However, it is consistent with thrust-fault deflections in the frontal part of the Cordilleran thrust belt to the west (fig. 1), the thrusts which overrode the southwest-plunging nose of the Blacktail-Snowcrest uplift and its bounding thrust system. The estimated fault separation along the Lima, Tendoy, and Armstead thrust systems of the frontal Cordilleran thrust belt is largely conjectural (fig. 3). However, in the case of the Lima thrust system it can be rather closely estimated as approximately 5 to 6 miles (8 to 9.6 km) based on deep-borehole and proprietary seismic reflection data. The Lima, Tendoy, and Armstead thrust systems were probably not one continuous system as suggested by the fault separation indicated on the palinspastic base (Fig. 3). A buried displacement transfer zone undoubtedly exists between each of the three thrust systems, but subsequent Tertiary to Quaternary cover and extensional events have obscured much of the frontal part of the Cordilleran thrust belt in the area such that much of the evidence of displacement transfer is obscured. The principle of mass conservation appears to require that shortening be conserved in closely adjacent segments of the Cordilleran thrust belt which were undergoing synchronous deformation. Therefore, it is reasonable to project 5 to 6 miles (8 to 9.6 km) of shortening northward from the Lima system along analogous thrusts of the frontal part of the thrust belt (Fig. 3). Upper Cretaceous synorogenic deposits of the Beaverhead Group either locally obscure or are involved in both the Laramide and Sevier-style deformation in the region, adding further complications but also providing constraints on the age and sequence of Cretaceous compressional deformation (Nichols and others, 1985; Perry and others, in prep.).

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FIGURE CAPTIONS

Figure 1. Index map of Lima, Montana, region, showing major physiographic and structural features and locations of drillholes; map modified from Perry and Sando (1983). Position of the Kidd "anticlinal axis" and Little Water synclinal axis are from Scholten and others (1955). Trend-line of the "Blacktail-Snowcrest arch" is from Scholten (1967); both this and the Kidd "axis" probably never represented true anticlinal axes. Both features appear to be closely similar in style to the Wind River uplift of Wyoming. The term uplift (i. e., Perry and others, 1981, 1983) is used in the present report to emphasize the similarity of the Blacktail-Snowcrest massif to other Laramide uplifts of the Rocky Mountain foreland. Drillholes 1 through 4 are described in Tables 1 through 4.

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EXPLANATION OF MAP SYMBOLS ON FIGURES 1 AND 3

Normal fault - bar and ball on downthrown side.

Thrust fault - sawteeth on upper plate.

Anticline, showing direction of plunge.

Syncline showing direction of plunge.

Drillhole with show of gas.

Drillhole without shows of oil or gas.

TABLE 1. Shell Oil Corp. no. 34X-13 Unit (drillhole 1, fig.1)
API no. 25-001-05007 AMSTRAT no. M-1704
T. 13 S., R. 5 W., NE SW SE Sec. 13
Beaverhead Co., Montana

D & A, 11/14/64 Elevation (KB) 6,806 ft (2,074 m)
Total depth 10,244 ft (3,122 m)

Stratigraphic unit	Depth to top in feet	Depth to top in meters
CRETACEOUS		
Mowry (?) Shale	3,780	1,152
Blackleaf Fm.	4,350	1,326
upper volcaniclastic unit	4,350	1,326
lower volcaniclastic unit	5,492	1,674
Flood Member	5,910	1,801
"Muddy Sandstone"	5,910	1,801
"Thermopolis Shale"	6,130	1,868
basal sandstone unit	6,208	1,892
Kootenai Formation	6,278	1,913
"gastropod" limestone member	6,278	1,913
redbed member	6,422	1,957
lower limestone mbr.	6,482	1,976
Pryor Conglomerate Member	6,609	2,014
JURASSIC		
Morrison Formation	6,660	2,030
Ellis Group	6,832	2,082
TRIASSIC		
Chugwater Group	6,900	2,103
Ankareh Redbeds	6,900	2,103
Thaynes Formation (eastern facies)	7,086	2,160
Woodside Formation	7,252	2,210
Dinwoody Formation	7,558	2,304
limestone member	7,952	2,424
PERMIAN		
Park City Formation	8,092	2,466
shale member	8,092	2,466
Shedhorn Sandstone	8,115	2,473
Phosphoria Formation	8,153	2,485
Tosi Chert Member	8,153	2,485
Retort Shale Member	8,204	2,501
Franson Member	8,220	2,505
Meade Peake Shale Member	8,293	2,528
Park City Formation Grandeur Member	8,298	2,529
PENNSYLVANIAN AND MISSISSIPPIAN		
Quadrant Formation	8,434	2,571
Amsden Formation	8,925	2,720
Horseshoe Shale Member?	9,078	2,767
MISSISSIPPIAN		
Madison Group	9,125	2,784
Mission Canyon Fm.	9,125	2,784
dolomite member	9,125	2,784
first anhydrite	9,630	2,935
Lodgepole Limestone	10,195	3,107
TOTAL DEPTH	10,244	3,122

TABLE 2. American Quasar Petroleum Company no. 29-1 Peet Creek-Federal
API no. 25-001-21004 AMSTRAT no. M-2890 (drillhole 2, fig. 1)
T. 14 S., R. 4 W., SW NE Sec. 29
Beaverhead Co., Montana

D & A, 4/10/78 Elevation (KB) 6944 ft (2117 m)
Total depth 12,226 ft (3727 m)

Stratigraphic unit	Depth to top in feet	Depth to top in meters
CRETACEOUS		
Cody (?) Shale	2,405	733
Frontier (?) Fm.	2,800	853
Mowry (?) Shale	4,225	1,288
Blackleaf Fm.	4,783	1,458
upper volcaniclastic unit	4,783	1,458
lower volcaniclastic unit	5,275	1,608
Flood Member	5,600	1,707
"Muddy Sandstone"	5,600	1,707
"Thermopolis Shale"	5,810	1,771
basal sandstone member	5,858	1,786
Kootenai Formation	5,925	1,805
"gastropod" limestone member	5,960	1,817
redbed member	6,087	1,855
lower calcareous member	6,173	1,882
Pryor Conglomerate Member	6,305	1,921
JURASSIC		
Morrison Formation	6,386	1,946
Ellis Group	6,605	2,013
TRIASSIC		
Ankareh Formation	6,710	2,045
Thaynes Formation (eastern facies)	6,868	2,093
Woodside Formation	7,090	2,161
Dinwoody Formation	7,500	2,286
limestone member	7,780	2,371
PERMIAN		
Park City Formation	7,908?	2,410?
shale member	7,908?	2,410?
Shedhorn Sandstone tongue	7,930	2,417
Phosphoria Formation	7,940	2,420
Tosi Chert Member	7,940	2,420
Retort Member	8,022	2,445
Park City Formation		
Franson Member	8,038	2,450
Phosphoria Formation		
Meade Peak Member	8,098	2,468
Park City Formation		
Grandeur Member	8,101	2,469
PENNSYLVANIAN AND MISSISSIPPIAN		
Quadrant Formation	8,148	2,484
sandstone and dolostone member	8,148	2,484
dolostone member	8,340	2,542
Amsden Formation	8,395	2,559
MISSISSIPPIAN		
(Lombard Formation absent)		
Kibbey? Formation	8,505?	2,592?
Mission Canyon Fm.	8,595	2,620
dolostone member	8,595	2,620
first anhydrite	9,050	2,758
Lodgepole Formation	9,638	2,938
DEVONIAN		
Three Forks Fm.	10,238	3,121
Sappington Member	10,238	3,121
black shale unit	10,300	3,139
Trident Member	10,310	3,143
Logan Gulch Member	10,397	3,169
Jefferson Dolomite	10,550	3,216
Maywood (?) Fm.	10,975	3,345
CAMBRIAN		
Meagher Formation	10,981	3,347
Wolsey Shale	11,330	3,453
Flathead Formation	11,360	3,463
PRECAMBRIAN		
Archean gneiss	11,384	3,470
TOTAL DEPTH	12,226	3,727

TABLE 3. Exxon Company no. 1 Myers-Federal (drillhole 3, fig. 1)
API no. 11-033-20001 AMSTRAT no. CW-2875
T. 14 N., R. 35 E., SW NE Sec. 14
Clark County, Idaho

D & A, 6/16/82 Elevation (KB) 6,975 ft (2,126 m)
Total depth 18,540 ft (5,651 m)

Stratigraphic unit	Depth to top in feet	Depth to top in meters
CRETACEOUS		
Upper Cretaceous sandstones undivided	0	0
Cody (?) Shale	7,038	2,145
Frontier (?) Fm.	7,260	2,213
Mowry (?) Shale	10,670	3,252
Blackleaf Formation	12,258	3,736
upper volcaniclastic unit	12,258	3,736
lower volcaniclastic unit	12,848	3,916
Flood Member	13,271	4,045
"Muddy Sandstone"	13,271	4,045
"Thermopolis Shale"	13,420	4,090
Kootenai Formation	13,555	4,132
"gastropod" ls. mbr.	13,605	4,147
redbed member	13,735	4,186
lower calcareous member	13,830	4,215
Pryor Conglomerate Member	13,983	4,262
JURASSIC		
Morrison Formation	14,052	4,283
Ellis Formation	14,242	4,341
TRIASSIC		
Chugwater Group	14,324	4,366
(Ankareh Formation absent)		
Thaynes Formation (eastern facies)	14,324	4,366
Woodside Formation	14,734	4,491
Dinwoody Formation	15,122	4,609
limestone member	15,325	4,671
shale member	15,490	4,721
PERMIAN		
Phosphoria and Park City Formations	15,540	4,737
Meade Peake Member	15,750	4,801
Grandeur Member	15,753	4,802

Stratigraphic unit	Depth to top in feet	Depth to top in meters
PENNSYLVANIAN AND MISSISSIPPIAN		
Quadrant Formation	15,776	4,809
sandstone and dolomite member	15,776	4,809
dolostone member	15,872	4,838
MAJOR UNCONFORMITY		
MISSISSIPPIAN		
Mission Canyon Fm.	15,895	4,845
dolostone member	15,895	4,845
first anhydrite	16,220	4,944
limestone member	16,458	5,016
Lodgepole Formation	16,880	5,145
Cottonwood Canyon Member	17,518	5,340
DEVONIAN		
Three Forks Formation	17,528	5,343
Sappington Member	17,528	5,343
black shale unit	17,560	5,352
Trident Member	17,575	5,357
Logan Gulch Member	17,676	5,388
Jefferson Dolomite	17,818	5,431
CAMBRIAN		
Meagher Dolomite	18,144	5,530
Pilgrim Limestone	18,185	5,543
Wolsey Shale	18,457	5,626
Flathead Sandstone	18,495	5,637
TOTAL DEPTH	18,540	5,651

TABLE 4. Amoco Production Company no.1 Snowline Grazing-Federal
T. 15 S, R. 7 W, SW NE SE Sec. 10 (drillhole 4, fig. 1)
Beaverhead County, Montana PRELIMINARY REPORT

Plugged & Abandoned 11/12/82 Elevation (KB) 6,983 ft (2,128 m)
Total depth 14,410 ft (4,392 m)

Stratigraphic unit	Depth to top in feet	Depth to top in meters
CRETACEOUS		
Upper Cretaceous sandstones undivided	0	0
Blackleaf Formation	8,695	2,650
Flood Member	10,298	3,149
Kootenai Formation	10,650	3,246
JURASSIC		
Morrison Formation	11,264	3,433
Ellis Formation	11,432	3,485
TRIASSIC		
Thaynes Formation	11,660	3,554
Woodside Formation	12,152	3,704
Dinwoody Formation	12,532	3,820
PERMIAN		
Phosphoria Formation	12,980	3,956
Retort Member	13,070	3,984
Meade Peak Member	13,192	4,021
PENNSYLVANIAN		
Quadrant Formation	13,248	4,038
MISSISSIPPIAN		
Mission Canyon Fm.	13,290	4,051
Lima thrust	14,165	4,318
Cretaceous sandstones undivided	14,165	4,318
TOTAL DEPTH	14,410	4,392

TABLE 5. Drilled thicknesses of lower Mesozoic and Paleozoic units in feet. Some thickness anomalies may be due to dip or minor faulting.

Stratigraphic unit	Drillhole 1*	Drillhole 2	Drillhole 3	Drillhole 4**
Kootenai Formation	383	433	467	614
Morrison Formation	172	214	185	168
Ellis Group	68	98	80	228
Ankareh & Thaynes Fms.	352	357	403	492
Woodside Formation	306	390	385	380
Dinwoody Formation	534	388	414	448
Park City & Phosphoria Formations	342	229	233	268
Quadrant Sandstone	491	234	112	42
Amsden Formation and/or Snowcrest Range Group	200	189	0	0
Mission Canyon Limestone	1070	992	853	875+
Lodgepole Limestone	--	571	604	--
Three Forks Formation	--	293	280	--
Jefferson Dolomite	--	405	321	--
Cambrian rocks	--	382	391	--

*Uncorrected for dip; dips believed to be of low magnitude.
**Uncorrected for dip; some units may dip steeply.