Petroleum Potential of Wilderness Lands in Wyoming-Utah-Idaho Thrust Belt

By Richard B. Powers

PETROLEUM POTENTIAL OF WILDERNESS LANDS IN THE WESTERN UNITED STATES

GEOLOGICAL SURVEY CIRCULAR 902-N

CONTENTS

ILLUSTRATIONS

TABLE

Petroleum Potential of Wilderness Lands in Wyoming-Utah-Idaho Thrust Belt

By Richard B. Powers

ABSTRACT

Three segments of the North American part of the Cordilleran thrust belt (north of Mexico) produce oil and gas—the Canadian Foothills, western Montana, and Wyoming-Utah-Idaho thrust belts. Between 1975 and 1983, 26 new (or indicated new) fields (at least 8 of them "giants") were found in the Wyoming-Utah-Idaho thrust belt; these fields have an estimated, ultimately recoverable 3.2 billion barrels of oil (BBO) and 16.5 trillion cubic feet (TCF) of gas, plus natural gas liquids. Most of this oil and gas is trapped in major (>50 MMBO, or >0.3 TCF of gas) and giant (100 MMBO, or 1 TCF of gas) fields, and not in numerous, smaller-size fields. This is significant because over 80 percent of the world's discovered oil and gas is in giant fields, and giant fields account for as much as 70 percent of the world's present production.

Four major thrust plates, which are oriented, generally, from north to south, are recognized in the province. All 26 fields discovered since 1975 are concentrated mainly in the southern one-third of the thrust belt and are located on, and controlled by, the folded leading edges of three of the four major thrust plates. Six wilderness tracts within the province are rated as having a high potential for the occurrence of oil and gas, one has a medium potential, and the remainder have either zero, low, or unknown oil and gas potential.

ACKNOWLEDGMENTS

The many, detailed reports on the surface geology and mineral potential of wilderness areas published by colleagues in the U.S. Geological Survey were a valuable source of information. I would like particularly to thank Steven S. Oriel for his helpful discussions on the overall surface geology of the thrust belt. Jerome W. Boettcher of Exxon Co. USA provided me with up-to-date information on the status of new-field wildcat gas discoveries in the area west of La Barge, Wyoming, that aided greatly in the evaluation of tracts in that area.

INTRODUCTION

A review has been made of the oil and gas potential of various categories of Wilderness Lands in the Wyoming-Utah-Idaho Thrust Belt province (fig. 1). The types of Wilderness Lands are shown on maps of Wyoming, Utah and Idaho prepared by the U.S. Bureau of Land Management (1981a,b,c). Tract numbers evaluated in the present study are shown on these maps. Six of the wilderness tracts have a high oil and gas potential, one has a medium potential, and the remainder have either zero, low, or unknown oil and gas potential.

The Wyoming-Utah-Idaho thrust belt straddles parts of western Wyoming, north-central Utah, and eastern Idaho and covers an area of 15,000 square miles (fig. 1). The northern boundary is placed at the south edge of the Snake River volcanic plain west of Jackson, Wyoming; the southern boundary is at the intersection of the Uinta Mountains just east of Salt Lake City; the eastern boundary is at the surface trace of the Darby-Prospect thrust fault, which separates the structurally deformed thrust belt from the undeformed Green River basin on the east; the western boundary is the surface trace of the Willard-Paris thrust on the east side of the Bear River Range (fig. 2).

GEOLOGIC FRAMEWORK

During a span of geologic time (Paleozoic-early Mesozoic) ranging from about 570 to 140 million years (m.y.) before the present, more than 60,000 feet of sand, silt, mud, and limy material was de-

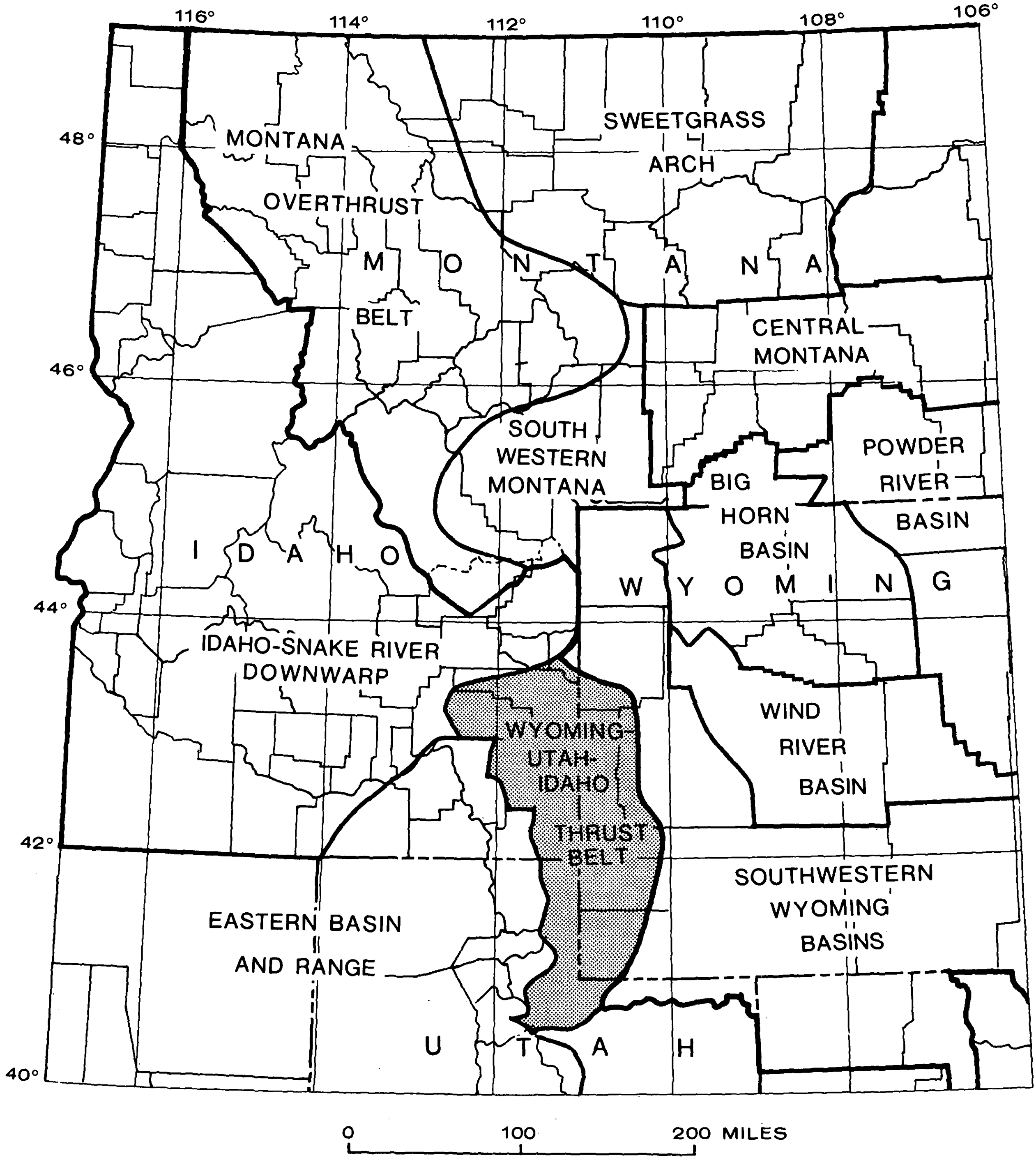

FIGURE 1.—Map showing location and boundaries of the Wyoming-Utah-Idaho Thrust Belt province in respect to the other petroleum provinces in the northern Rocky Mountain region.

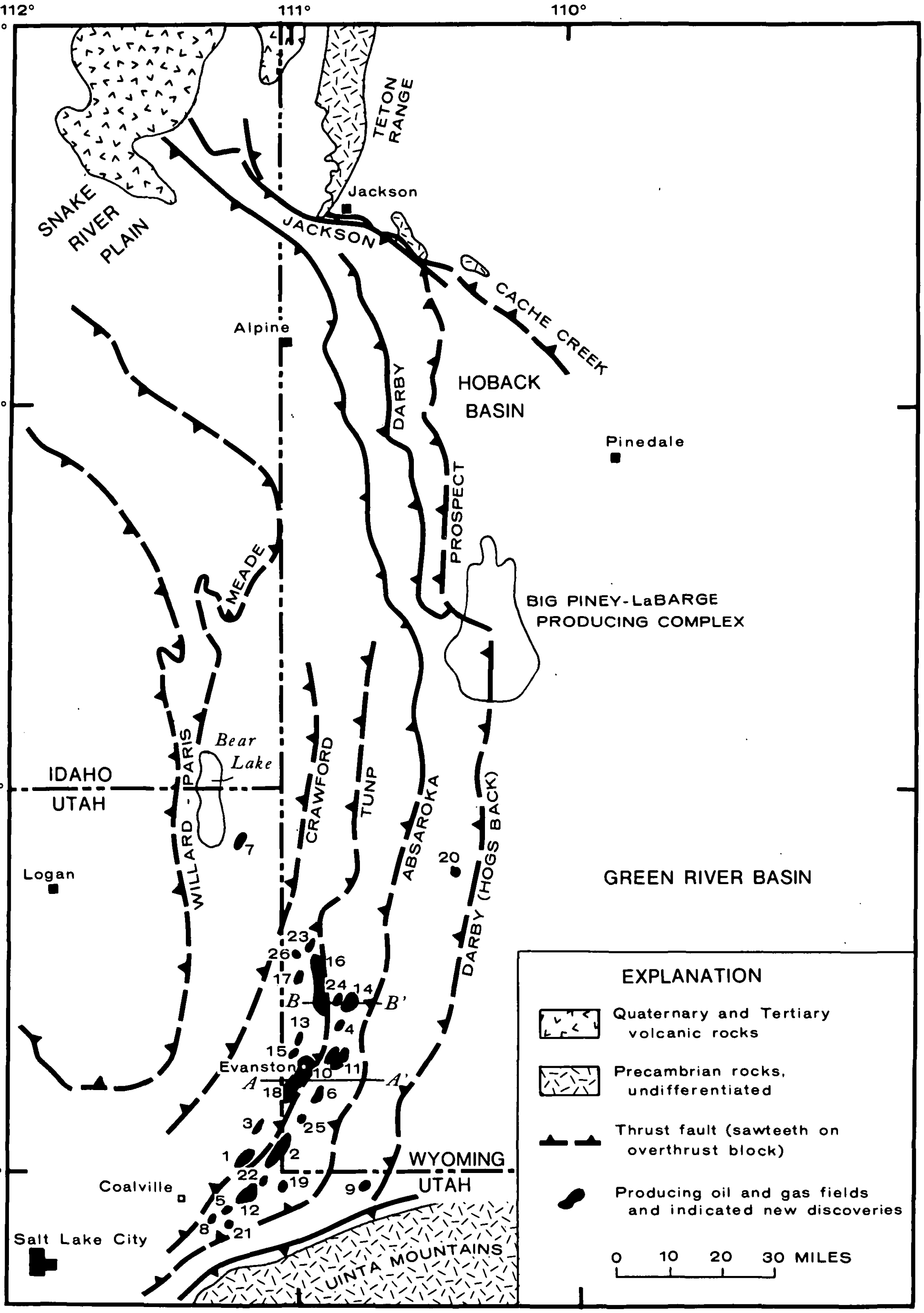

FIGURE 2.—Index map of Wyoming-Utah-Idaho thrust belt showing principal tectonic features, major thrust faults, oil and gas fields (numbered), and new-field wildcat discovery wells since 1975. Numbers coded to field names are shown on table 1. Cross section *A–A* ′ shown in fig. 3 (Modified from Powers, 1977, 1980; Lamerson and Royse 1980; Petroleum Information, 1981; and Ver Ploeg and De Bruin, 1982). Cross section *B–B*′ is shown in figure 5.

posited in an ocean basin that was located some distance west of the present thrust belt. About 140 m.y. ago, in latest Jurassic time, the ocean basin (or miogeosyncline) began to be deformed, and the mass of sedimentary rocks within it was strongly folded and thrust eastward by compressional forces from the west. Compression continued episodically for about 85 m.y., or until early Eocene time (55 m.y.) after which normal (extensional) faulting occurred within the thrust-fold belt until the present. Eastward horizontal movement on most of the individual thrust sheets exceeds 5 miles.

Four major thrust-fault systems are recognized in this province and are named after the major thrusts involved (fig. 2). They are from oldest to youngest, and from west to east: (1) Willard-Paris, (2) Meade-Crawford, (3) Absaroka, and (4) Darby-Prospect-Hogsback (Royse, 1979). Prior to horizontal shortening of some 65 miles due to west-east folding and thrusting, the width of this rock sequence was about 130 miles. The chief structural characteristic of this province, as a result of all of the tectonic pushing, sliding, and crumpling is that older rocks have been thrust over, and now overlie, younger rocks. This is illustrated in a cross section (fig. 3), in which rocks as old as Devonian and Cambrian in the hanging wall (overthrust block) are thrust over rocks as young as Cretaceous in the footwall (subthrust block), forming an anticlinal fold, a possible trap for oil and gas, in the hanging wall.

PETROLEUM POTENTIAL FACTORS

The oil and gas (petroleum) potential of the thrust belt, as well as for most sedimentary basins, is controlled by several factors critical to the generation, migration, and trapping of petroleum and must be present in natural balance, in order for discrete hydrocarbon accumulations to occur. The most important of these factors are (1) number and thickness of porous reservoir rocks, (2) organic-rich fine-grained rocks that are the source of hydrocarbons, (3) thermal maturation of the source rocks that allows the generation and expulsion of hydrocarbons, (4) structural or stratigraphic traps such as folds (anticlines), faults, or lensing of reservoir rocks, (5) tight, dense (impermeable) rocks over the trap that act as a seal to prevent the upward and lateral escape of hydrocarbons, and finally (6) correct timing as to generation and migration of hydrocarbons relative to the forming of a trap. All of these factors are present in the Wyoming-Utah-Idaho thrust belt.

RESERVOIR ROCKS

Fifteen formations produce oil or gas in anticlinal traps in the thrust belt. These formations represent eight different geologic systems, ranging in age from Cretaceous through Ordovician (fig. 4). In contrast, many producing basins in the United States have only one or two formations within a single geologic period that are oil or gas bearing.

Rocks of the Jurassic and Triassic Systems contain six reservoir formations that are productive of oil or gas, including the prolific Nugget Sandstone, which is the main oil or gas reservoir in 11 fields. Paleozoic rocks contain five productive reservoirs ranging in age from the Permian Phosphoria Formation through the Ordovician Bighorn Dolomite. These formations are the major gas and condensate (light, high gravity crude oil similar to natural gasoline) reservoirs in seven recently discovered fields in the thrust belt (table 1, fig. 4). The Madison Group of Mississippian age, which is the principal Paleozoic reservoir in these fields, has substantial intercrystalline porosity developed in limestones and dolomites of the Mission Canyon Limestone (fig. 4).

SOURCE AND SEAL ROCKS

Nine formations in the thrust belt contain possible source rocks ranging from the Cretaceous Frontier Formation to the Devonian Darby Formation (fig. 4). However, the only probable source rocks, for which documented and published data exist, are those of Cretaceous age (Frontier Formation, Aspen Shale, and Bear River Formation). Warner (1982) conducted extensive geochemical studies and concluded that the oil trapped in Jurassic-Triassic reservoir rocks in fields along the Ryckman Creek–Pineview structural trend on the Absaroka thrust (fig. 2) was generated in source rocks in the footwall Cretaceous sequence that was overriden by the Absaroka thrust plate about 75 m.y. ago. This conclusion is supported by data from a variety of analytic techniques used to make oil-to-oil and oil-to-source rock correlations. The source of sour gas (gas high in sulfur content) and high-gravity oil in Paleozoic reservoirs in the fields along the Whitney Canyon–Carter Creek trend west of the Tunp thrust (fig. 2) is more difficult to identify with any degree of certainty.

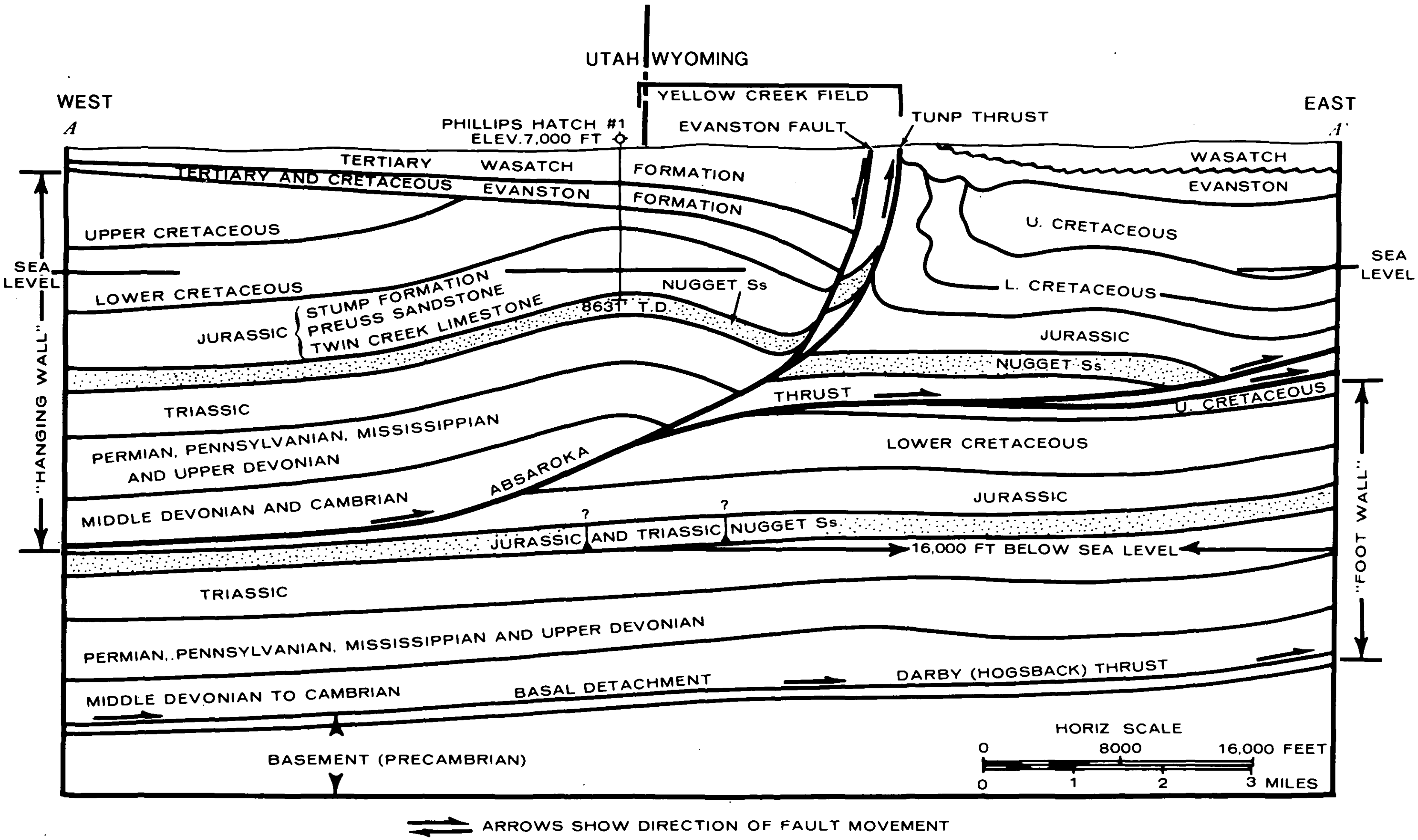

FIGURE 3.—Diagrammatic west to east structural cross section in vicinity of Summit County, Utah, and Yellow Creek field, Uinta County, Wyoming, showing the relation between an anticline in the "hanging wall" and rocks in the "footwall" (subthrust block). Older Devonian and Cambrian rocks have been thrust over younger Cretaceous and Jurassic rocks along the Absaroka thrust fault (basement is not involved in thrusting). (Slightly modified from Royse and others, 1975, Plate II, and Conrad, 1977). Line of cross section is shown in figure 2.

Geologic Age		Formation or Group	Oil or Gas	Thickness Range
Tertiary		Green River Fm.		0–8,000′
		Wasatch-Evanston Fms.		
Cretaceous	Late	Adaville Fm.		6,000′–16,000′
		Hilliard Fm.		
		Frontier Fm.	RS ●	
	Early	Aspen Shale	RS ●	10,000′
		Bear River Fm.	RS ✷	
		Gannett Group		
Jurassic		Stump Fm.	R ●	500′–1,000′
		Preuss Ss. <Salt[1]	R ✷	
		Twin Creek Ls.	RS ✷	1,200′–3,500′
		Gypsum Spring Mbr.		
Jurassic(?) and Triassic(?)		Nugget Ss.	R ✷	500′–2,000
Triassic		Ankareh Fm.	R ✷	2,000′–7,000′
Early Triassic		Thaynes Fm.	RS ☼	
		Woodside Fm.		
		Dinwoody Fm.	R ☼	
Permian		Phosphoria Fm.[2]	RS ☼c	400′–5,000′
Pennsylvanian		Weber Ss.	R ☼c	750′–4,000′
Mississippian		Madison Group: Mission Canyon Ls.[3]	R ☼c	1,000′–7,000′
		Madison Group: Lodgepole Ls.	RS ☼c	
Devonian		Darby Fm[4] / Three Forks Fm.	RS ☼c	500′–3,000
		Darby Fm[4] / Jefferson Fm.		
Ordovician		Bighorn Dolomite	RS ☼c	250′–2,000′
Cambrian		Gallatin Fm.		1,500′–5,000′
		Gros Ventre Fm.		
		Flathead Ss.		
Precambrian		Uinta Mtn. Group		>20,000′

- ● Oil productive
- ✷ Oil and gas productive
- ☼ Gas productive
- ☼c Gas with condensate productive
- R- Known or potential reservoir rock
- S- Known or potential source rock

[1] of Maher (1976)

[2] And equivalent strata

[3] Brazer limestone of some authors

[4] Locally in Wyoming

FIGURE 4.—Generalized stratigraphic chart of the Wyoming-Utah-Idaho thrust belt showing productive formations and known or potential reservoir and source rocks. (Modified from Hayes, 1976; Powers, 1977, 1983; Lageson and others, 1980; and Ver Ploeg and De Bruin, 1982.)

However, the identical sulfur content and chromatographic character of condensate from the Paleozoic and Jurassic-Triassic reservoirs suggest that both were generated from the same Cretaceous source rocks (Warner, 1982), or possibly at the same time from rocks of different ages.

The key factors that led to the presence of oil and gas fields in the thrust belt appear to be (1) the presence of an extensive area of organic-rich Cretaceous source rocks at peak maturation in the footwall of, and in contact with, the Absaroka thrust, (2) generation of oil and gas from these rocks after being overridden and buried by the Absaroka plate, and consequent expulsion of the oil and gas, (3) migration of the expelled hydrocarbons laterally and upward into Jurassic, Triassic, and Paleozoic reservoir rocks in available hanging-wall traps, and (4) sealing over the traps by impermeable shale, anhydrite, or halite (salt) caprocks (Royse, 1979).

STRUCTURE

As discussed earlier, a wedge of Paleozoic and Mesozoic sedimentary rocks was compressed from west to east into a zone about one-half of its original width, resulting in the thrust folds of the present Wyoming-Utah-Idaho thrust belt. However, in this province only the sedimentary rock section is involved in folding and thrusting and is structurally detached from basement crystalline rocks (Precambrian granite) by a regional "décollement." This décollement condition has also been referred to as "thin-skinned" structure by Rodgers (1963) in describing folds and faults in a thrust belt involving only the upper strata lying on a décollement, beneath which the structure differs. In other words, the basement is passive and only the overlying sedimentary rock sequence is actively involved in the shortening of the total section in the province (fig. 3). Nearly all of the present oil and gas fields in the thrust belt have been trapped in asymmetric and overturned anticlinal folds in the hanging wall of the Absaroka thrust plate. Most of the folds have numerous, additional imbricate thrust faults included within their overall configuration. Vertical structural relief or amplitude of the traps ranges from 500 to more than 4,500 feet, and areal size ranges from about 3 to more than 50 square miles. The greater the vertical relief and area of the fold, the larger the amount of oil or gas it can trap. Many of the new discoveries in the thrust belt are major fields and some are estimated to be giant fields in size. A major field is defined informally as one that is estimated to ultimately produce 50 MMBO or more, or 300 BCF or more of combustible gas (Johnston, 1980, p. 1303). A giant field is defined as one that is expected to produce more than 100 MMBO, or 1 TCF of combustible gas (Halbouty, 1980, p. 1).

Prior to 1975, lack of success in finding oil or gas traps in most of the prominent surface anticlines present in the thrust belt eventually led to the conclusion that perhaps the structures that held oil and gas did not necessarily lie directly beneath the surface structures. The problem then became a matter of finding the right tool, or method, that would enable explorationists to look thousands of feet below the surface and identify anticlines similar to those on the surface that might trap oil or gas. The problem was solved by applying an improved method of subsurface mapping employing advanced seismic-reflection tools that were the result of a breakthrough in seismic data processing and mapping, coupled with modern, sophisticated computer technology.

OIL AND GAS FIELDS

Table 1 summarizes basic data relating to new fields and indicated new-field wildcat discoveries in the Wyoming-Utah-Idaho thrust belt since 1975. One of the largest of these fields is the Whitney Canyon–Carter Creek gas field in Uinta and Lincoln Counties, Wyoming, located 13 miles north of the town of Evanston (fig. 2, table 1). The field was discovered in late 1977 on a major north-south-trending, slightly overturned anticline on the hanging wall of the Absaroka thrust plate. The overall anticline is actually made up of three individual structures with total structural closure (vertical relief) exceeding 4,500 feet (fig. 5). The anticline is 16 miles long and 4 miles wide occupying an area of 60 square miles (one and one-half townships).

An unusual feature of this field is that production of sour gas, averaging 12 percent hydrogen sulfide (H_2S), and condensate comes from six separate reservoirs, including the Permian Phosphoria Formation, Pennsylvanian Weber Sandstone, Mississippian Mission Canyon and Lodgepole Limestones, Devonian Darby Formation and Ordovician Bighorn Dolomite (figs. 4 and 6). A seventh reservoir, the Triassic Thaynes Formation, which is productive of sweet gas and con-

TABLE 1.—*New fields discovered since 1975 and indicated (one well drilled) recent new-field wildcat discoveries in the Wyoming-Utah-Idaho thrust belt. Numbered location of fields is shown on figure 2. Age of formations is shown on figure 4. (Modified and updated from Petroleum Information, 1981, and Ver Ploeg and De Bruin, 1982.)*

Field name and number	Producing formations	Hydrocarbon type	Thrust plate	Discovery date
1. Anschutz Ranch	Twin Creek Limestone	Sweet gas and condensate	Absaroka (east)[1]	10/78
	Nugget Sandstone	Sweet gas and condensate	Absaroka (west)	
	Weber Sandstone	Sour gas and condensate		
2. Anschutz Ranch East	Nugget Sandstone	Sweet gas and condensate	Absaroka (east)	12/79
3. Cave Creek	Phosphoria Formation	Sour gas and condensate	Absaroka (west)	10/79
	Weber Sandstone	do		
	Mission Canyon Limestone	do		
4. Clear Creek	Nugget Sandstone	Oil and sweet gas	Absaroka (east)	08/78
5. Elkhorn Ridge	Twin Creek Limestone	Oil and sweet gas	Absaroka (east)	09/77
6. Glasscock Hollow	Nugget Sandstone	Sweet gas and condensate	Absaroka (east)	09/80
7. Hogback Ridge	Dinwoody Formation	Dry sweet gas	Crawford	10/77
	Phosphoria Formation	Sour gas		
8. Lodgepole	Twin Creek Limestone	Oil and sweet gas	Absaroka (east)	03/77
	Nugget Sandstone	do		
9. Mill Creek (temporarily abandoned)	Darby Formation	Oil and sweet gas	Darby-Hogsback	04/80
10. Painter Reservoir	Nugget Sandstone	Oil and sweet gas	Absaroka (east)	10/77
11. Painter Reservoir East	Nugget Sandstone	Sweet gas and condensate	Absaroka (east)	08/79
12. Pineview	Frontier Formation	Oil and sweet gas	Absaroka (east)	01/75
	Stump Formation	do		
	Twin Creek Limestone	do		
	Nugget Sandstone	do		
13. Red Canyon	Weber Sandstone	Sour gas and condensate	Absaroka (west)	12/79
14. Ryckman Creek	Nugget Sandstone	Oil and sweet gas	Absaroka (east)	09/76
	Ankareh Formation	Sweet gas and condensate		
	Thaynes Formation	do		
15. Thomas Canyon	Phosphoria Formation	Sour gas and condensate	Absaroka (west)	08/81
	Madison Group	do		
16. Whitney Canyon–Carter Creek	Thaynes Formation	Sweet gas and condensate	Absaroka (west)	08/77
	Phosphoria Formation	Sour gas and condensate		
	Weber Sandstone	do		
	Mission Canyon Limestone	do		
	Lodgepole Limestone	do		
	Darby Formation	do		
	Bighorn Dolomite	do		
17. Woodruff Narrows	Bighorn Dolomite	Sour gas and condensate	Absaroka (west)	04/81
18. Yellow Creek	Twin Creek Limestone	Sweet gas and condensate	Absaroka (west)	07/76
	Phosphoria Formation	Sour gas and condensate		
	Weber Sandstone	do		

TABLE 1.—*New fields discovered since 1975 and indicated (one well drilled) recent new-field wildcat discoveries in the Wyoming-Utah-Idaho thrust belt. Numbered location of fields is shown on figure 2. Age of formations is shown on figure 4. (Modified and updated from Petroleum Information, 1981, and Ver Ploeg and De Bruin, 1982.)* —Continued

Field name and number	Producing formations	Hydrocarbon type	Thrust plate	Discovery date
19. [2]Aagard	Frontier Formation Stump Formation	Oil and sweet gas do	Absaroka (east)	03/82
20. Horsetrap	Madison Group	Sweet gas and condensate	Darby-Hogsback	06/82
21. Lodgepole South	Frontier Formation	Sweet gas	Absaroka (east)	09/78
22. North Pineview	Nugget Sandstone	Sweet gas and condensate	Absaroka (east)	09/82
23. Road Hollow	Bighorn Dolomite	Sour gas and condensate	Absaroka (west)	11/81
24. Ryckman Creek West	Ankareh Formation	Oil and sweet gas	Absaroka (east)	02/82
25. Coyote Creek	Nugget Sandstone	Sweet gas and condensate	Absaroka (east)	11/82
26. West Carter Creek	Mission Canyon Limestone Bighorn Dolomite	Sour gas and condensate do	Absaroka (west)	11/82

[1]Position of field east or west of Tunp imbricate thrust of main Absaroka thrust.
[2]Numbers 19–26 are indicated new-field wildcat discoveries.

densate, is the exception in this dominantly sour gas field. Depth to production ranges from 9,200 feet to 14,000 feet in these formations. Warping (folding) of the upper, main Absaroka thrust sheet has evidently been the main reason for the great amount of structural closure on the overall anticline.

To gain some idea of the productive capability of this field, one well, the Amoco-Champlin No. 457–A (fig. 6), was flow-tested in the Paleozoic reservoirs for a total recovery rate of nearly 75 million cubic feet (MMCF) of gas and 1,294 barrels of condensate (B.C.) per day; even more significant is the fact that a 30-foot-thick section of the Mission Canyon Limestone reservoir, alone, flowed 32 MMCF of gas per day.

PRODUCTIVE TRENDS

A fairly well defined, arcuate northeast-southwest pattern or trend exists of fields discovered in the southern part of the thrust belt (fig. 2). In addition, within this trend, a separation occurs between predominantly oil and sweet gas fields in Jurassic and Triassic reservoirs east of the Tunp thrust and dominantly sour gas and condensate fields in Paleozoic reservoirs west of the Tunp thrust (fig. 2, table 1). However, all these fields are common to the Absaroka thrust trend. Only one gas field, Hogback Ridge, is located on the Crawford-Meade thrust trend and only one recently discovered (sweet) gas field in a Mississippian reservoir (Horsetrap field), and three indicated sour gas discoveries (not listed) are located on the Darby-Hogsback thrust trend (fig. 2, table 1). Although temporarily abandoned at present, the Mill Creek field (table 1, no. 9) is also located on the Darby-Hogsback trend. This two-well field seems to be the exception to all of the fairly well defined patterns discussed above in that the discovery well flowed 154 barrels of sweet, 46 degree A.P.I. gravity green oil from a Paleozoic sandstone reservoir (Devonian Three Forks Formation). Interruptions in the established pattern of fields, trends, hydrocarbon type, and age of reservoir as shown by the anomalous Mill Creek field may indicate the possibilty of a different oil and gas field trend on the Darby-Hogsback thrust to the north and northwest along the leading edge of this thrust plate, as well as the Absaroka thrust trend.

QUALITATIVE RATINGS OF WILDERNESS LANDS

METHODS OF EVALUATION

Tracts were rated on the basis of available geologic information, both published and unpub-

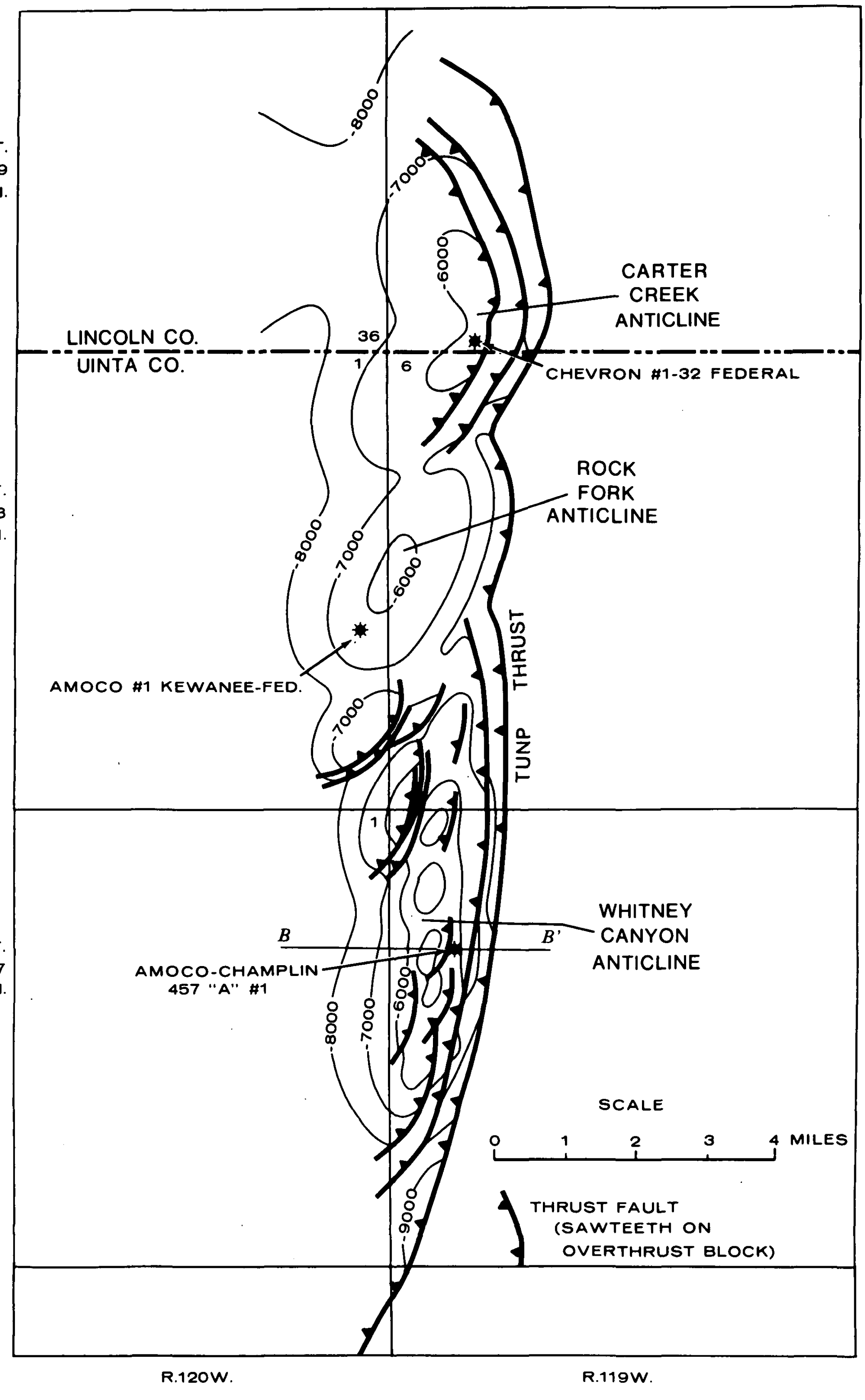

FIGURE 5.—Structure contour map of the Whitney Canyon–Carter Creek field, Wyoming. Contours are on top of the Mississippian Mission Canyon Limestone; contour interval is 1,000 ft. Contours show the three large anticlines that make up the field. Also shown are field discovery wells (solid circle with rays—oil and gas productive) on each of the three anticlines. (Modified from Hoffman and Balcells-Baldwin, 1982). Cross section *B–B'* is shown in figure 6.

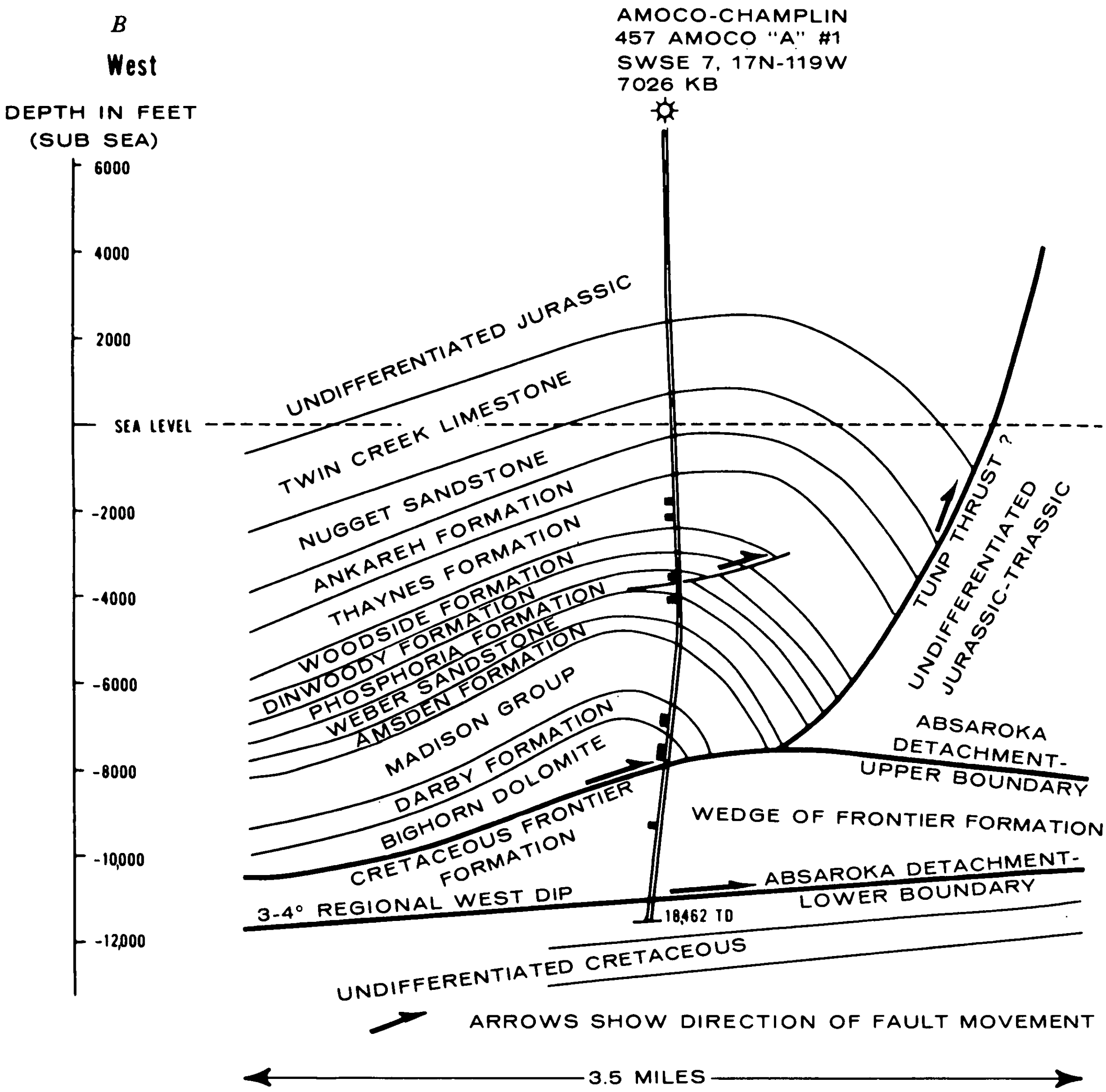

FIGURE 6.—Simplified west-east structural cross section across Whitney Canyon–Carter Creek field in the Wyoming-Utah-Idaho thrust belt, showing hanging wall fold closed against the Tunp thrust. Also shows "warping" (folding) of the main Absaroka thrust plate. Black rectangles indicate producing intervals. (Courtesy of Amoco Production Co.) Line of section is shown in figures 2 and 5.

lished, taking into account the distribution and types of oil and gas accumulations in producing and abandoned fields. The analysis is weighted heavily toward the known or interpreted presence and distribution of reservoir rocks, petroleum-source rocks, geologic history, and stratigraphic and structural style favorable for oil and gas accumulations in the Wyoming-Utah-Idaho thrust belt.

PETROLEUM POTENTIAL RATINGS

High potential.—Geologic environment highly favorable for occurrence of oil and gas accumulations. Area is near or on trend with existing production from structural and (or) stratigraphic traps.

Medium potential.—Geologic environment favorable for the discovery of oil and gas fields.

Contains known reservoir rocks and hydrocarbon-source beds. Includes some areas of sparse subsurface control or areas where known or expected field size will be small.

Low potential.—Geologic environment interpreted to have low potential for oil and gas. Includes areas of poor or unknown hydrocarbon-source bed richness and reservoir quality. Generally includes areas of sparse or no well control and (or) expected thin section of sedimentary rocks.

Zero potential.—Mostly comprises areas with exposed Precambrian rocks or very thin sedimentary cover with no potential for occurrence of sealed structural or stratigraphic traps.

Unknown potential.—Generally includes areas of no well control where Tertiary volcanic intrusions and volcaniclastic rocks are present on the surface. This cover, plus lack of subsurface well and geophysical control, makes prediction of hydrocarbon potential nearly impossible. Includes some areas where Precambrian igneous and metamorphic rocks are thrust over Phanerozoic sedimentary rocks of unknown potential. Lack of control does not mean that no oil and gas potential exists, but only that the potential can not reasonably be determined with present data.

Six wilderness tracts within the thrust belt are rated to have a high oil and gas potential on the basis of possessing geologic characteristics favorable for the occurrence of petroleum. These six tracts, as identified by the Bureau of Land Management (1981a–c), are discussed in the following section for four cluster groupings, three clusters in Wyoming and one cluster in Idaho.

1. Tracts 040–221 and 040–223 (U.S. Bureau of Land Mangement, 1981c), in cluster 15 (C. W. Spencer, Wyoming, chapter M), western Lincoln County, Wyoming.—Two wildcat tests were drilled in the northern part of tract 040–221 by Gulf Oil Co. and Sohio Petroleum (1978, 1982) on the Crawford thrust. Gulf drilled to a total depth of 15,992 feet and reported minor gas shows in Mesozoic rocks. Sohio set production casing in its well and tested perforations in the Permian Phosphoria Formation (fig. 4) at a total depth of 17,131 feet. Good gas shows were indicated in this well, but the amounts were not sufficient to justify commercial production.

2. Tract 040–110 (U.S. Bureau of Land Mangement 1981c), in cluster 15 (C. W. Spencer, Wyoming, chapter M), western Sublette County, Wyoming.—Exxon drilled a new-field wildcat discovery (Graphite Hollow) within the east half of this tract in 1982, on the Darby-Hogsback thrust. The discovery flowed 5 MMCF of low BTU gas (25 percent methane) from the Madison Group (fig. 4) below 16,000 feet. In addition, Exxon drilled two new-field wildcat discoveries, Lake Ridge and Fogarty Creek, directly north of the northern boundary of the tract. The Lake Ridge discovery well flowed 6 MMCF of low Btu gas from the Madison at 16,318 feet, and Fogarty Creek flowed 20 MMCF of similar type gas from the Madison at 16,291 feet, including a small percentage of helium.

3. Tract 4–102 (U.S. Bureau of Land Mangement, 1981c), in cluster 17 (C. W. Spencer, Wyoming, chapter M), southern Teton County, Wyoming.—Only the southwestern portion of this tract, which lies between the Darby and Prospect thrusts where they form separate thrust sheets in the northern part of the thrust belt, is rated as having a high potential. Directly east of the tract Rainbow Resources Inc. completed a new-field wildcat gas discovery in the Frontier Formation (fig. 4) in 1977. The well is shut-in at present pending future field development.

4. Tract 4–613 (U.S. Bureau of Land Management, 1981c), in cluster 16 (C. W. Spencer, Wyoming, chapter M), and tract W4–613 (U.S. Bureau of Land Management, 1981a) in Idaho cluster 7 (C. A. Sandberg, Idaho, chapter F).—These tracts straddle the Wyoming-Idaho State line in the vicinity of Alpine, Wyoming, but are grouped together for this discussion on the basis of geologic similarity. The Darby thrust trends northwest in the eastern part of the tracts and the Absaroka thrust parallels the Darby trend in the central part of the tracts. A wildcat well, the Allday No. 1 Government, was drilled in the westernmost part of tract W4–613 in 1966 to a depth of 5,760 feet immediately northeast of the Palisades Creek picnic area in the Targhee National Forest, Bonneville County, Idaho. Live oil shows were encountered in porous and fractured Ordovician limestones from 1,252 to 1,256 feet, 1,348 to 1,354 feet, and 1,368 to 1,375 feet in the well; live oil was bleeding from fractures in the lower zone. Surface mapping indicates that the well was located on the hanging wall (fig.3) of the

Thompson imbricate thrust above the buried Absaroka thrust plate (fig. 2). Live oil shows at these shallow depths are a positive indication that oil and gas are being generated and are migrating within the rock system on the Absaroka thrust plate in this general area. The same formations, reservoir and source rocks (fig. 4), and trapping structures are present here, as well as a favorable thermal-maturation history, in a framework similar to that in the productive southern area of the thrust belt (figs. 2 and 3).

Tracts 34–3 Islands and 34–4 Islands (U.S. Bureau of Land Management, 1981a) in cluster 6 (C. A. Sandberg, Idaho, chapter F), eastern Bonneville County, Idaho, are rated to have a medium oil and gas potential. The surface area of this cluster consists of volcanic cover (not prospective for oil and gas); however several old, shallow wildcat wells drilled nearby indicate that sedimentary rocks are present in the subsurface. These tracts, therefore, are rated as possessing medium oil and gas potential. The small part of a tract, referred to as cluster 18, in Utah at the western end of the Uinta Mountains, is rated as having low petroleum potential. (C. M. Molenaar and C. A. Sandberg, Utah, chapter K). The remaining tracts in the Wyoming-Utah-Idaho thrust belt are rated to have a zero or unknown petroleum potential.

SUMMARY

The Wyoming-Utah-Idaho thrust belt possesses the following critical requirements that make it a major oil and gas producing province:

1. The presence of four dominant regional thrust trends that act as controlling factors in localizing oil and gas fields.

2. Proved occurrence of similar trap types on the hanging wall (overthrust block) of three of the regional thrust trends.

3. Organic-rich, thermally mature source rocks ranging in age from Cretaceous through Devonian.

4. Thick, porous and permeable clastic and carbonate reservoir rocks productive of oil and gas.

5. The discovery of 26 new oil and gas fields and indicated new production in additional recent wildcat wells, during the past 8 years.

There are approximately 500,000 acres of designated and proposed Wilderness Lands within the Wyoming-Utah-Idaho thrust belt. Eighty-five percent of these lands are assessed as having high to medium petroleum potential (high potential, 78.5 percent, and medium potential, 6.5 percent). An additional 1.2 percent are judged to have low petroleum potential, with the remaining 13.8 percent as having zero petroleum potential.

REFERENCES CITED

Conrad, J. F., 1977, Surface expression of concentric folds and apparent detachment zone (décollment) near Cokeville, Wyoming, *in* Wyoming Geological Association Guidebook Symposium, 29th Annual Field Conference, Rocky Mountain thrust belt geology and resources, p. 385–390.

Halbouty, M. T., ed., 1980, Giant oil and gas fields of the decade 1968–1978: American Association of Petroleum Geologists Memoir 30, 596 p.

Hayes, K. H., 1976, A discussion of the geology of the southeastern Canadian Cordillera and its comparison to the Idaho-Wyoming-Utah fold and thrust belt, *in* Hill, J. G., ed., Rocky Mountain Association of Geologists Symposium on geology of the Cordilleran Hinzeline, p. 59–82.

Hoffman, M. E., and Balcells-Baldwin, R. N., 1982, Gas giant of the Wyoming thrust belt: Whitney Canyon–Carter Creek field, *in* Geologic studies of the Cordilleran thrust belt, Powers, R. B., ed., Rocky Mountain Association of Geologists, v. 2, p. 613–618.

Johnston, R. R., 1980, North American drilling activity in 1979: American Association of Petroleum Geologists Bulletin, v. 64, no. 9, p. 1295–1330.

Lageson, D. R., Lowell, J. D., Lamerson, P. R., and Royse, Frank, Jr., 1980, Wyoming-Utah Overthrust Belt structural style, field guide to American Association of Petroleum Geologists, Trip No. 5, June, 1980, Denver, Colorado, 34 p. plus maps and photos.

Lamerson, P. R., and Royse, Frank, Jr., 1980, Thrust belt structures, Part B, *in* Wyoming-Utah overthrust belt structural style, field guide to American Association of Petroleum Geologists, Trip No. 5, June 1980, Denver, Colorado, 34 p. plus maps and photos.

Maher, P. D., 1976, Rewarding Peneview field in Utah presents complex geology, high risk: Oil and Gas Journal, June 14, p. 96–99.

Petroleum Information Corporation, Denver, Colorado, 1981, The Overthrust Belt, 251 p.

Powers, R. B., 1977, Assessment of oil and gas resources in the Idaho-Wyoming Thrust Belt, *in* Wyoming Geological Association Guidebook, 29th Annual Field Conference, Rocky Mountain thrust belt geology and resources, p. 629–637.

——1980, Oil and gas potential of the Wyoming-Utah-Idaho overthrust belt in relation to its Canadian Foothills thrust belt analog (abs.): American Association of Petroleum Geologists Bulletin, v. 54, no. 5, p. 767.

——1983, Geologic framework and petroleum potential of the greater Bob Marshall Wilderness Area, western Montana thrust belt: U.S. Geological Survey, Open-File Report, 21 p. [in press].

Rodgers, John, 1963, Mechanics of Appalachian foreland folding in Pennsylvania and West Virginia: American Association of Petroleum Geologists Bulletin, v. 47, no. 8, p. 1527–1536.

Royse, Frank, Jr., 1979, Structural geology of the western Wyoming-northern Utah thrust belt and its relation to oil and gas; American Association of Petroleum Geologists Distinguished Lecture: Oil and Gas Journal, February 12, v. 77, no. 7, p. 155–156.

Royse, Frank, Jr., Warner, M. A., and Reese, D. L., 1975, Thrust belt structural geometry and related stratigraphic problems, Wyoming-Idaho-northern Utah, *in* Rocky Mountain Association of Geologists Symposium on deep drilling frontiers in the central Rocky Mountains, p. 41–54.

U.S. Bureau of Land Management, 1981a, State of Idaho wilderness status map, scale 1:1,000,000.

——1981b, State of Utah wilderness status map, scale 1:1,000,000.

——1981c, State of Wyoming wilderness status map, scale 1:1,000,000.

Warner, M. A., 1982, Source and time of generation of hydrocarbons in Fossil Basin, western Wyoming thrust belt, *in* Geologic studies of the Cordilleran thrust belt, Powers, R. B., ed., Rocky Mountain Association of Geologists, v. 2, p. 805–816.

Ver Ploeg, A. J., and DeBruin, R. H., 1982, The search for oil and gas in the Idaho-Wyoming-Utah salient of the overthrust belt; Geological Survey of Wyoming, Report of Investigations no. 21, 108 p.