DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

MISCELLANEOUS FIELD STUDIES MAP
MF-1619-A
PAMPHLET

MINERAL RESOURCE POTENTIAL OF THE WEST AND EAST PALISADES ROADLESS AREAS, IDAHO AND WYOMING

By

Steven S. Oriel, John C. Antweiler, and David W. Moore, U.S. Geological Survey[1]
and
John R. Benham, U.S. Bureau of Mines

STUDIES RELATED TO WILDERNESS

Under the provisions of the Wilderness Act (Public Law 88-577, September 3, 1964) and related acts, the U.S. Geological Survey and the U.S. Bureau of Mines have been conducting mineral surveys of wilderness and primitive areas. Areas officially designated as "wilderness," "wild," or "canoe" when the act was passed were incorporated into the National Wilderness Preservation System, and some of them are now being studied. The act provided that areas under consideration for wilderness designation should be studied for suitability for incorporation into the Wilderness System. The mineral surveys constitute one aspect of the suitability studies. The act directs that the results of such surveys are to be made available to the public and be submitted to the President and the Congress. This report discusses the results of a mineral survey of the West (W 4613) and East (E 4613) Palisades Roadless Areas, Targhee and Bridger National Forests, Teton and Bonneville Counties, Idaho, and Teton and Lincoln Counties, Wyoming. The West and East Palisades Roadless Areas were classified as further planning areas during the Second Roadless Area Review and Evaluation (RARE II) by the U.S. Forest Service, January 1979.

MINERAL RESOURCE POTENTIAL SUMMARY STATEMENT

Field studies from 1979 to 1982 of the West and East Palisades Roadless Areas, which lie within the Idaho-Wyoming thrust belt, document the presence of hydrocarbon source beds, reservoir formations, fluid seals, structures, and hydrocarbon thermal maturities comparable to those in producing oil and gas fields farther south in the belt. Therefore, the areas have high potential for oil and gas resources; all parts of the areas are under lease application for oil and gas. High-grade phosphate beds within the study area contain 98 million tons of inferred phosphate rock resources but they are thinner and less accessible than those being mined from structurally higher thrust sheets to the southwest. Coal seams in the northern part of the area are too thin, sparsely distributed, and lenticular to constitute a resource. Moderately pure limestone is present, but it is available from other sources closer to markets. Abundant sand and gravel deposits lie along the boundaries and just outside of the roadless areas but also are available from sources closer to markets. Silver, copper, molybdenum, and lead geochemical anomalies from stream-sediment and rock samples offer little promise for the occurrence of metallic mineral resources, except for those metal concentrations that may augment the value of phosphate in the Phosphoria Formation. The potential for geothermal resources is untested by drilling but regarded as low, despite thermal phenomena at nearby sites.

GEOGRAPHIC SETTING

The West and East Palisades Roadless Areas, treated here as one study area, encompass 247,090 acres, or about 386 square miles, of the Snake River Range along the Idaho-Wyoming border. The area extends from Alpine and the Grand Canyon of the Snake River in Wyoming, northward to the Teton Basin near Victor, Idaho (fig. 1). Jackson, Wyo., lies 7 mi east of the northern part of the area. The Palisades area is bounded on the southwest by Swan and Grand Valleys, the site of the Bureau of Reclamation Palisades Reservoir, used for both irrigation and the generation of electrical power.

Altitudes range from 10,025 ft at Mount Baird to about 5,600 ft in Swan Valley. The crest of the range contains numerous peaks above 9,500 ft. The flanks of the range are heavily forested, in contrast to its crest. The sinuous east boundary of the area was defined by the U.S. Forest Service to exclude logging trails to timbered areas, some of which have been clear-cut.

Only pack trails traverse the roadless areas. Ruggedness and inaccessibility of terrain made the use of helicopters desirable and cost-effective for study of

[1]With contributions from Don R. Mabey, U.S.G.S.

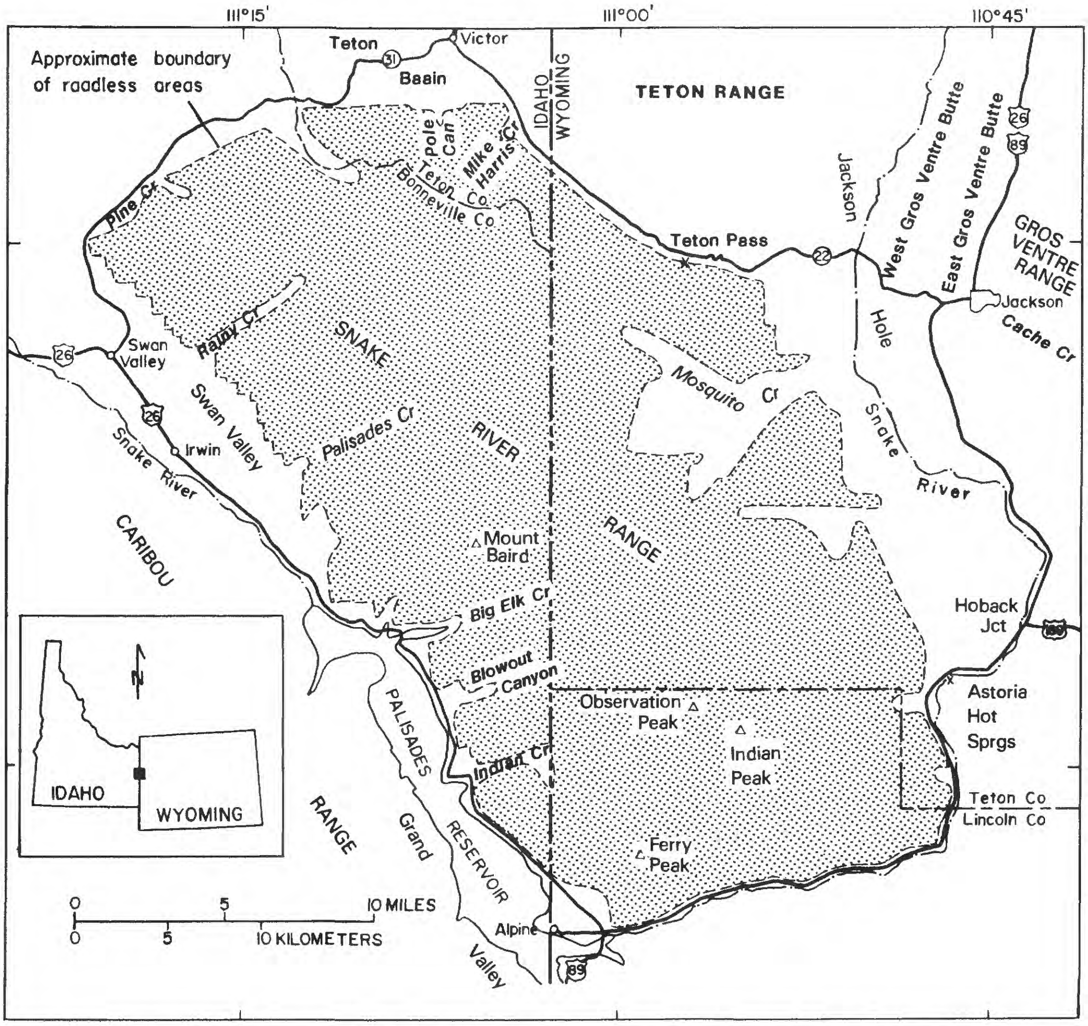

FIGURE 1.--INDEX MAP SHOWING LOCATION OF THE PALISADES ROADLESS AREAS, TETON AND BONNEVILLE COUNTIES, IDAHO, AND TETON AND LINCOLN COUNTIES, WYOMING.

the area. Field work, which was begun by the U.S. Bureau of Mines during the summer of 1979, and by the U.S. Geological Survey in the summer of 1980, was facilitated by the earlier work of others (fig. 2) and was completed in 1982.

GEOLOGY, GEOPHYSICS, AND GEOCHEMISTRY

The Snake River Range lies in the northern part of the arcuate Idaho-Wyoming-Utah salient of the Cordilleran foreland thrust belt. The salient (here termed the Idaho-Wyoming thrust belt, for brevity) extends southeastward and southward from the late Cenozoic Snake River Plain in Idaho, and then southwestward toward the western end of the mainly early Cenozoic Uinta Mountains in north-central Utah.

Bedrock of the Snake River Range, as throughout the thrust belt, consists almost entirely of westward-thickening Paleozoic and Mesozoic stratified bodies of resistant limestone, quartzite, and dolomite, that form ridge crests, and of weaker mudstone, claystone, and sandstone, that form valleys. The various rock units are summarized in figure 3 and in the description of map units.

The strata were translated tens of miles eastward and northeastward during Cretaceous and early Tertiary time, in large thrust sheets that are folded and cut by imbricate thrust slices (Oriel and Moore, 1985), all of which documents moderately intense compressive stresses. The principal thrust sheets in the study area are, from west to east (from uppermost to lowest, and generally from oldest to youngest), the St. John, the Absaroka, the Darby, and the Jackson (or Prospect Mountain) (fig. 4). The strata were intruded after thrusting (probably in mid-Eocene time) by igneous rocks exposed now in several small bodies at Indian Peak.

The youngest deformation to affect the Palisades region is the product of extensional stresses, which formed the Snake River Plain volcanic Province, as well as the Basin and Range Province, whose eastern boundary overlaps (is overprinted on) the thrust belt. The southwestern margin of the Snake River Range has been rising since Miocene time, concurrently with the depression of the Swan Valley asymmetrical graben, and both have been tilted and rotated downward to the northeast. The Teton Range block, which adjoins the Palisades area on the north, has also been rising and rotating (down to the west) since Miocene time (Oriel and Moore, 1985), and adjoining older thrust sheets have been further tilted and deformed; folds within the thrust sheets have been overturned (Dimitre Dunn, 1983). During Miocene and Pliocene time, very coarse to fine detritus shed by the rising mountain blocks was deposited in adjoining grabens and basins (Swan Valley, Jackson Hole, and Teton Basin), which were also invaded by volcanic flows and volcaniclastic strata.

Geophysical investigations of the Palisades area included both aeromagnetic and reconnaissance gravimetric surveys. Almost all anomalies on the residual aeromagnetic map of the region (U.S. Geological Survey, 1981) can be attributed to mapped rock units. The most prominent anomalies are produced by basalt flows extending into Swan Valley from the northwest. Basalt and andesite also account for smaller but intense anomalies north of the study area at the head of Coal Creek Meadows in the Teton Range and on the Gros Ventre Buttes in Jackson Hole. Another anomaly of lower amplitude coincides with an exposure of Archean basement rocks along the Teton Pass road near the head of Trail Creek. Mainly rhyolitic volcanic rocks account for widespread anomalies in Teton Basin, along the ridge north of Mosquito Creek, and along Swan Valley. Intrusive bodies at Indian Peak produce a small local magnetic anomaly. The southwest part of the Swan Valley graben is well defined on the aeromagnetic map; the northeast part, although evident, is less prominent, because the proportion of rhyolite in Tertiary strata within the graben is greater on the southwest. A broad, elliptical, deeper anomaly, centered over the bend of Snake River at Astoria Hot Springs, cannot be related to exposed rocks.

The reconnaissance gravity survey defines major negative anomalies in the valleys, which suggest about 5,000 ft of fill in Swan Valley, perhaps more in Teton Basin, and about 10,000 ft in Jackson Hole. Data are insufficient within the Snake River Range to define local structural features, and the intrusives at Indian Peak have no gravity expression. Gravity data obtained along the ridge west of Long Spring and Long Spring Basin, north of Alpine, confirm that dense Paleozoic rocks exposed there are underlain by less dense Tertiary strata (Albee and Cullins, 1975, section). The thrust sheets are not apparent from either the gravity or aeromagnetic data.

The geochemical survey consisted of collecting and analyzing 603 rock, stream-sediment, panned-concentrate, and water samples (Antweiler and others, 1984; Hopkins and others, 1984). The results define geochemical anomalies for several elements in three different geologic settings: stratabound silver and copper in the mid-Mesozoic Nugget Sandstone; base metals and molybdenum associated with Tertiary intrusive igneous rocks; and several metals in the Permian Phosphoria Formation.

The Nugget Sandstone in the study area, as elsewhere in the thrust belt, hosts stratabound deposits of copper and silver, locally accompanied by sparse gold, zinc, lead, or other base metals. The metal concentrations are associated with local oil stains and bleached zones (Love and Antweiler, 1973). Sulfate beds in the basal gypsiferous part of the Twin Creek Limestone directly overlie the Nugget and may have a genetic bearing on metal concentrations. Malachite- and azurite-stained sandstone or quartzite was found in the Nugget at four localities. Selected specimens contain as much as 2 percent copper and 150 ppm silver; concentrations of other base metals, including zinc, are relatively minor. One sample along a tributary of the South Fork of Big Elk Creek contains a little gold (0.1 ppm). Observed mineralized rocks are neither extensive nor continuous.

Weak anomalies (only slightly greater than background) were found for some metals in intrusive igneous rocks and adjoining strata at and near Indian Peak. Hornblende diorite and porphyritic hornblende andesite contain as much as 150 ppm copper, 1 ppm silver, and 10 ppm molybdenum; intruded strata contain comparable metal concentrations. However, most samples of the intrusive body at Indian Peak, and several related dikes, contain only traces of these metals, and indicate little possibility of resource potential in exposed rocks. Anomalous amounts of several elements were found in gossan fragments in talus downslope from two andesite sills intruded into

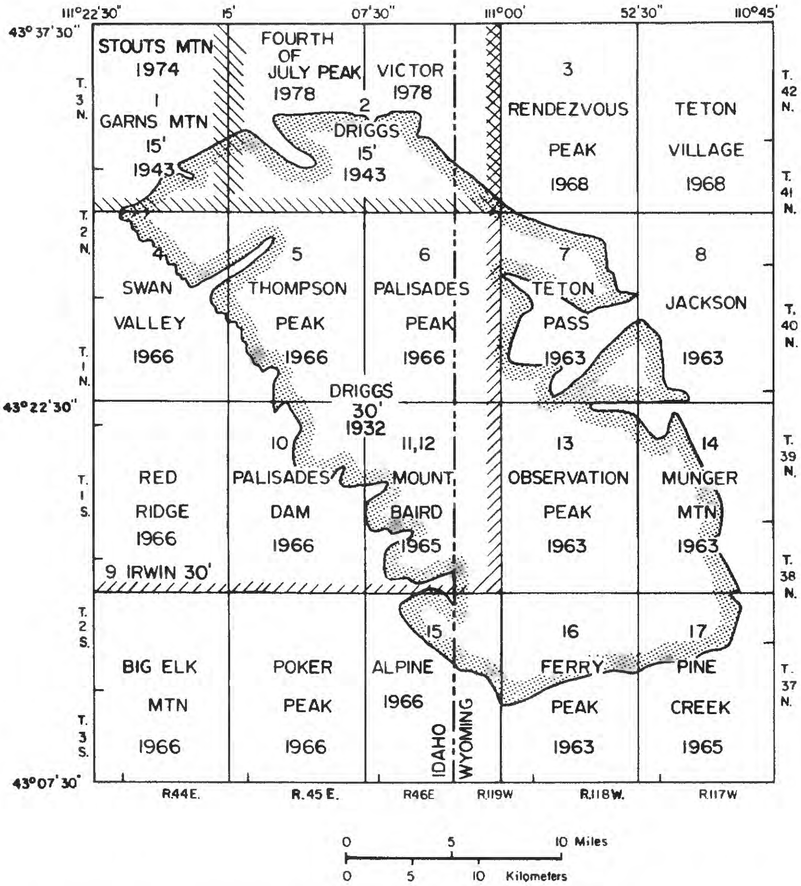

FIGURE 2.--INDEX MAP OF SOURCES OF DATA USED FOR STUDY OF PALISADES AREA

Shows topographic quadrangle base maps (by quadrangle name and date of edition). Principal sources of geologic data are shown by numbers listed below. Hachures show the boundaries of geologic maps covering areas larger than 7 1/2-minute quadrangles.

1. Staatz, M. H., and Albee, H. F., 1966.
2. Pampeyan, E. H., Schroeder, M. L., Schell, E. M., and Cressman, E. R., 1967.
3. Schroeder, M. L., 1972.
4. Jobin, D. A., and Schroeder, M. L., 1964b.
5. Jobin, D. A., and Soister, P. E., 1964.
6. Jobin, D. A., 1965.
7. Schroeder, M. L., 1969.
8. Love, J. D., and Albee, H. F., 1972.
9. Gardner, L. S., 1961.
10. Jobin, D. A., unpublished data.
11. Woodward, N. B., 1979.
12. Moore, D. W., Woodward, N. B., and Oriel, S. S., 1984.
13. Albee, H. F., 1973.
14. Albee, H. F., 1968.
15. Albee, H. F., and Cullins, H. L., 1975.
16. Jobin, D. A., 1972.
17. Schroeder, M. L., Albee, H. F., and Lunceford, R. A., 1981.

Map symbol (Fig. 4)	Geologic age		Formation or group	Oil or gas	Thickness (feet)
Qu	QUATERNARY		undifferentiated		
Tvc	TERTIARY	Late	volcaniclastic rocks and conglomerate		0-5000′
Ti	TERTIARY	EOCENE(?)	intrusive rocks		
Ku	CRETACEOUS	Late	Frontier Formation	RS ●	2000′+
		Early	Aspen Shale	RS ●	2000′
			Bear River Formation	RS ✹	1000′
			Gannett Group		550′-750′
Ju	JURASSIC		Stump Formation	R ●	
			Preuss Sandstone / salt	R ✹	300′
			Twin Creek Limestone	RS ✹	760-1,100′
JTR n	JURASSIC(?) and TRIASSIC(?)		Nugget Sandstone	R ✹	400′
TR u	TRIASSIC		Ankareh Formation	R ✹	500′-550′
	EARLY TRIASSIC		Thaynes Formation	RS ☼	400′-900′
			Woodside Formation		400′-800′
			Dinwoody Formation	R ☼	440′-600′
uPz	PERMIAN		Phosphoria Formation[1]	RS c☼	200′-220′
	PENNSYLVANIAN		Wells Formation	R c☼	1000′
			Amsden Formation	R c☼	400′-700′
	MISSISSIPPIAN		Madison GROUP: Mission Canyon Ls.[2]	R c☼	700′-1000′
			Madison GROUP: Lodgepole Limestone	RS c☼	400′-800′
lPz	DEVONIAN		Darby Fm.: Three Forks Fm. / Jefferson Fm.	RS c☼	400′-600′
	ORDOVICIAN		Bighorn Dolomite	RS c☼	400′-500′
	CAMBRIAN		Gallatin Formation		200′
			Gros Ventre Formation		650′-900′
			Flathead Sandstone		200′-250′
p€	PRECAMBRIAN		Archean gneisses, intrusive rocks		

● Oil productive
✹ Oil and gas productive
☼ Gas productive
[1] And equivalent strata
c☼ Gas with condensate productive
R Known or potential reservoir rock
S Known or potential source rock
[2] Brazer limestone of some authors

Figure 3.--GENERALIZED STRATIGRAPHIC CHART FOR THE NORTHEASTERN PART OF THE IDAHO-WYOMING THRUST BELT. Shows formations identified as hydrocarbon source beds and productive reservoirs farther south in the belt. (Modified from Hayes, 1976, p. 80, and Powers, 1983, p. N6)

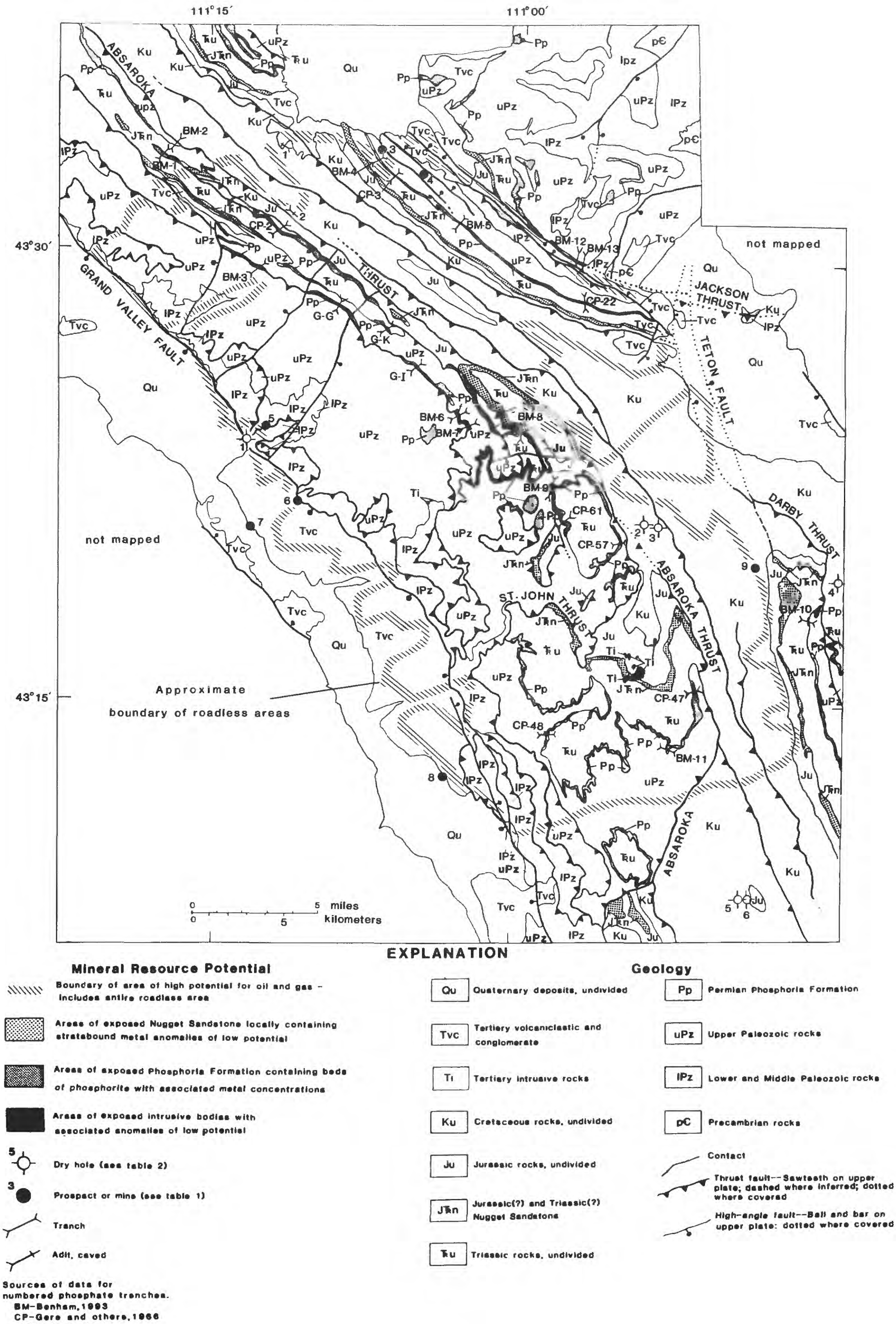

FIGURE 4.--MAP SHOWING SIMPLIFIED GEOLOGY AND MINERAL RESOURCE POTENTIAL IN THE PALISADES ROADLESS AREAS, IDAHO AND WYOMING.

the Mississippian Lodgepole Limestone near Big Elk Creek, east of Mount Baird. One sample contains 2.0 percent Cu, 50 ppm Ag, 0.15 percent As, 500 ppm Mo, and 0.15 percent Pb, and another specimen contains molybdenite and other metallic sulfides. The andesite sills are exposed in cliffs inaccessible for sampling, but limestone above and below them is not appreciably enriched in any of these elements. The mineralization associated with intrusives in the Palisades area is significantly less than that at the similar-appearing mid-Eocene Caribou Mountain stock (Huntsman, 1977; 1984), about 24 mi to the west-southwest.

The Phosphoria Formation contains small concentrations of several valuable metals. Stream sediments below the Phosphoria are enriched in base metals, silver, chromium, nickel, vanadium, molybdenum and cadmium. Analyses of samples of the Phosphoria Formation from trenches range widely in metal content; among the highest concentrations are: 33 ppm Ag, 940 ppm Cr, 0.12 percent Pb, 0.30 percent V, and 1.40 percent Zn.

EXPLORATION AND MINING ACTIVITIES

Oil and gas leases have been applied for, or issued for, the entire Palisades area. Several helicopter-supported geophysical crews were conducting seismic-reflection surveys in and near the study area during the summers of 1979 through 1983. More than a half-dozen proprietary reflection lines cross the area, representing a substantial investment by the petroleum industry.

The Snake River Range includes a small part of the phosphate-bearing lands in Idaho, Wyoming, Montana, and Utah, that were withdrawn from public entry in 1910 by the Secretary of Interior. Ownership rights to phosphate rock and certain other minerals were separated from surface rights in 1914, and the leasing law of 1920 permits mining of phosphate deposits. No leases or lease applications for phosphate have been issued in the Palisades area.

Pine Creek is the only mining district in the area (Benham, 1983). Its boundaries are vague, but the district lies within the Snake River Range along Pine Creek. Several coal claims (table 1) were located as early as 1903, but very little coal was mined. Coal mines in similar rocks to the northwest, outside the area and on the northeast flank of the Big Hole Mountains, were larger and more productive.

From 1922 to 1928, numerous claims were staked as "limerock" placers in Mike Harris and Pole Canyons. Limestone quarried on a small scale from Pole Canyon was used for rip-rap.

Some southwestern parts of the Palisades area were classified by the U.S. Geological Survey as potentially valuable for geothermal steam and associated geothermal resources. Applications have not been submitted for any geothermal leases.

A total of 71 mining claims have been located within the study area. Thirteen were lode claims, 19 were 160-acre coal claims, 35 were for limestone, and 4 were placer claims. There are no active or patented claims.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

Oil and Gas

The Palisades area has a high oil and gas resource potential. The area lies in the northern part of the Idaho-Wyoming thrust belt which extends into northern Utah. Numerous highly productive oil and gas fields have been found (Petroleum Information, 1981; Ver Ploeg and De Bruin, 1982; Lamerson, 1982; Powers, 1983) and continue to be found, according to press reports, about 100 mi south in southwestern Wyoming and northern Utah. The same rock formations are present throughout the thrust belt, including the same hydrocarbon source beds, the same potential reservoirs, and the same impermeable seals. Comparable structures, including anticlines that may entrap oil and gas both above and below thrust faults, are also present, as is comparable thermal maturity of source rocks. Moreover, eastward thinning and facies changes of most Paleozoic and Mesozoic units, which are inclined predominantly to the west, are favorable for the presence of numerous stratigraphic, as well as structural, traps.

Major sources of hydrocarbons throughout the thrust belt (fig. 3) are organic-rich shales in all Cretaceous units overlying the Gannett Group and in the Permian Phosphoria Formation; the total organic carbon content of these rocks is one weight percent or more (Warner, 1982). Cretaceous source beds are present within and beneath the Jackson and Darby thrust sheets in the Palisades area; they also underlie the northeastern part of the Absaroka thrust sheet throughout the Snake River Range. Favorable Cretaceous source rocks also underlie the Absaroka sheet, as shown in an exploratory hole drilled at Praeter Mountain, in the SE1/4SE1/4, sec. 15, T. 35 N., R. 118 W., a few miles south of the Palisades area (ARCO Exploration Company, in Lageson, 1984, p. 410). Phosphoria source rocks are present within, and underlie, all major thrust sheets. Significant source beds are also present in Mississippian strata (Sando and others, 1981, p. 1442) and probably, in most other Paleozoic and lower Mesozoic units, which have been studied insufficiently but have been observed to contain locally abundant organic debris. An exploratory wildcat borehole, the Allday No. 1 Government (table 2), was drilled in 1966 in the westernmost part of the study area to a depth of 5,760 ft. The site is directly 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 carbonate rocks at depths of from 1,252 to 1,256 ft, 1,348 to 1,354 ft, and 1,368 to 1,375 ft. Live oil was bleeding from fractures in the lower zone. Thus, hydrocarbon sources have been accessible to these dolomite strata. Thermal maturation and peak generation of hydrocarbons from Paleozoic sources probably preceded thrusting; the assumption that these hydrocarbons migrated out of the region before the development of favorable structural traps (Warner, 1982) overlooks the probable role of stratigraphic traps in retaining some hydrocarbons.

TABLE 1.--CLAIMS AND PROSPECTS IN THE PALISADES AREA
[from Benham, 1983]

Map no.	Name	Location	Workings	Sample data
1	Unnamed coal prospect	NE1/4NW1/4 sec. 30, T. 3 N., R. 45 E., Idaho. In Wood Canyon; Lower Cretaceous Bear River Formation	Five-inch coal seam in caved adit	One sample analyzed as lignite A coal
2	Shu-Fly No. 2 coal	SW1/4SW1/4 sec. 5, T. 2 N., R. 45 E., Idaho. Along North Fork Rainey Creek; Upper Cretaceous Frontier Formation	Two-foot coal bed with calcite stringers in caved adit	Two samples analyzed as high volatile C bituminous coal
3	Silver King Nos. 1-10	NW1/4NW1/4 sec. 26, T. 2 N., R. 45 E., Idaho. In Pole Canyon; Mississippian Mission Canyon Limestone	Two limestone quarries	CaO in eight samples ranged from 51.2 to 56.1 percent
4	Trail Creek Nos. 1-10 Birch Placers (lime rock) Nos. 1-8	NE1/4NE1/4 sec. 36, T. 2 N., R. 45 E., Idaho. Along Mike Harris Creek; Mississippian Mission Canyon Limestone	Two small pits and dozer scrape	CaO in five samples ranged from 44.9 to 56.1 percent
5	Arts Happy Day Nos. 1, 2, 3 Lodes	Sec. 19 and 20, T. 1 N., R. 45 E., Idaho. On and near Palisades Creek; St. John thrust fault, with altered zones, crosses the claim; country rock is limestone	None	Three samples; no significant assays
6	Bluebird Lodge	SW1/4SW1/4 sec. 32. T. 1 N. R. 45 E., Idaho. In Sheep Creek Canyon; Quartzite and quartzite conglomerate. No economic minerals	One pit- 8 ft by 4 ft, 1 ft deep	One sample; no significant assays
7	Townview 20 acre placer (south of study area boundary)	NW1/4NW1/4 sec. 8, T. 1 S., R. 45 E., Idaho. 1/4 mi east of Palisades; Talus consisting of unconsolidated andesite cobbles, silt, and clay	None	Two pan samples; one contained three very small particles of gold
8	Tripoli No. 1 160 acre (65 ha) placer	W1/2W1/2 sec. 27, T. 2 S., R. 46 E., Idaho. Unconsolidated sand and gravel	None	Two pan samples; no gold detected
9	Virginia Gold No. 14 160 acre (65 ha) placer	NE1/4 sec. 24, T. 39 N., R. 117 W., Wyo. 1/2 mi west of mouth of Coburn Creek; unconsolidated sand and gravel	None	Five pan samples; no gold detected

TABLE 2.--DRY HOLES DRILLED FOR PETROLEUM NEAR PALISADES STUDY AREA

Map no.	Operator	Borehole	Location	Completion date	Total depth (feet)
1	Edwin Allday	43-24 Federal	NE1/4SE1/4 sec. 24, T. 1 N., R. 44 E., Ida.	Unknown	5,760
2	Shell Oil	23-8 Teton Federal	NE1/4SW1/4 sec. 8, T. 39 N., R. 117 W., Wyo.	11-23-81	10,299
3	Getty Oil	1-Teton	NE1/4SE1/4 sec. 8, T. 39 N., R. 117 W., Wyo.	4-25-79	9,300
4	Chevron USA	1-21 Astoria Unit-Federal	SE1/4SE1/4 sec. 21, T. 39 N., R. 116 W., Wyo.	10-11-82	16,350
5	Delhi Oil Corp.	1-A Unit	SE1/4SW1/4 SE1/4 sec 25., T. 37 N., R. 117 W., Wyo.	12-22-50	4,699
6	True Oil	44-25 Greys River	SE1/4SE1/4 sec. 25, T. 37 N., R. 117 W., Wyo.	1-17-72	14,861
(South of map)	Sunmark Exploration	1 Praeter Mountain --Federal	SE1/4SE1/4 sec. 15, T. 35 N., R. 118 W., Wyo.	10-30-81	14,284

Reservoir beds in the thrust belt are present in, and produce from, almost all stratigraphic units from the Ordovician Bighorn Dolomite to Cretaceous sandstones (fig. 3), all of which occur in the study area. The Jurassic(?) and Triassic(?) Nugget Sandstone is the most productive unit, but Mississippian limestones and Pennsylvanian sandstones in the Wells Formation also contain oil. Intergranular porosity in sandstone and clastic limestone, and intercrystalline porosity in coarser dolomite are augmented by fracture porosity produced during compressive deformation. Sufficient shales are present throughout the sequence to provide required seals.

The presence of intrusive bodies within the Snake River Range and evidence of elevated geothermal gradients north and west of the range prompted sampling for thermal data. Of the 34 samples collected within the range, including four near Indian and Observation Peaks, one was from Ordovician strata, one from the Triassic, and the remainder from Mississippian to Permian beds. Conodont color alteration indices (CAI) for all samples range from 1.0 to 2.0 (B. R. Wardlaw, written commun., Nov. 11, 1983), well within the range (oil-generation "window") of optimum thermal maturity for oil.

Structures favorable for the entrapment of oil (antiforms and fault-truncated wedges) are abundant throughout the range. Structures like those that are buried and productive to the south are now exposed to erosion in the Palisades area, so hydrocarbons that may have been present have escaped. Nevertheless, comparable structures are also inferred to be present at depth, beneath the several thrust sheets and slices, as indicated by exposed structural relations: folds plunge beneath thrust sheets.

The high potential assigned here and by others (Powers, 1978, 1983; Spencer, 1983) to the Palisades area for oil and gas is based on the presence of favorable source beds, potential reservoirs and seals, structural and stratigraphic traps, and a favorable thermal regime, all of which are comparable to those in the already proven, highly productive southern part of the Idaho-Wyoming thrust belt.

Two exploratory tests have been drilled within the study area by the Shell Oil and Getty Oil companies at sites close to one another along Fall Creek, in sec. 8, T. 39 N., R. 117 W., Wyoming. Both were dry holes. The proprietary data used as a basis for siting these tests are unavailable to us, so that we are unable to evaluate them. Failure of these tests does not diminish the high resource potential for the study area.

Phosphate Rock

Beds of phosphate rock are present within the Permian Phosphoria Formation in the Palisades area. The formation is widely exposed (fig. 4) but its continuity is disrupted by thrust faults.

Moderately rich phosphorite beds (containing as much as 36 percent P_2O_5 in one seam) are present at four stratigraphic levels within the Phosphoria Formation, but few are sufficiently thick to be of commercial value. These four levels are: in the Retort Shale Member of the upper part of the formation, at or near the top, at and slightly above the middle, and at or near the base of the Meade Peak Phosphatic Shale Member in the lower part of the formation.

Twenty-three stratigraphic sections of the Meade Peak Phosphatic Shale Member have been sampled along a total strike length of 74 mi. At 13 of these sections, trenches were dug and the phosphate rock was sampled by U.S. Bureau of Mines personnel during the 1980 field season; U.S. Geological Survey analyses of these samples are reported by Motooka and others (1984). Data for the other 10 sections are from previous work by the U.S. Geological Survey (Gardner, 1944; Sheldon, 1963; Gere and others, 1966). Of the 23 sections, 13 are complete; the others are incomplete because of faulting or partial cover. Each of the 23 sections was examined for phosphate rock zones containing at least 14 percent P_2O_5, a concentration regarded by Benham (1983) as marginally economic (see also U.S. Geological Survey, 1982, p. 9). The thinnest zone considered in calculating resources is 1.2 ft and the thickest, 11.9 ft; weighted grades range from 14.20 to 27.97 percent P_2O_5. Two sections have no significant phosphate-rock zones and one section has four.

A dip mining distance of 250 ft was used to calculate resource tonnage. These calculations yield 98 million tons of inferred phosphate-rock resources (Benham, 1983). Strata containing these resources also contain an average of 2.39 percent fluorine, which might be recovered as a byproduct, and lesser amounts of vanadium and uranium (Sheldon, 1963; Gere and others, 1966).

Units of phosphate rock that contain 24 or more percent of P_2O_5 are thinner and less accessible in the Palisades area than those units from 20 to more than 30 ft thick that are now being mined in the structurally higher Meade thrust sheet in the Soda Springs and Pocatello areas to the southwest (U.S. Geological Survey, 1977, v. 1, p. 48).

Coal

Coal seams occur in the Cretaceous Frontier and Bear River Formations, which trend northwest along the northeastern part of the Snake River Range. The seams are thin, steeply dipping, and discontinuous. Two areas have been mined for small amounts of coal, the Shu-Fly No. 2 Claim (W1/2 sec. 5, T. 2 N., R. 45 E.) and an unnamed prospect (N1/2 sec. 30, T. 3 N., R. 45 E.) in Idaho. The coal at the Shu-Fly No. 2 Claim is high volatile C bituminous and that at the unnamed prospect is lignite. The amount of coal remaining is small, but could supply some local needs (Benham, 1983).

Limestone

The Mississippian Mission Canyon Limestone, exposed in the Jackson, Absaroka, and St. John thrust sheets, contains relatively pure limestone. Exposures of the limestone in the Jackson thrust sheet trend northwest along ridges from south of Teton Pass to Pole Canyon, a distance of 12 mi, are as much as 1/2 mi wide and the beds dip 10^{o} to 65^{o} SW.

Two groups of claims were located along these limestone exposures: the Silver King claims (numbers 1-10), and the Trail Creek claims (numbers 1-8) and their associated Birch limerock placers claims (numbers 1-8). Only one property, the Silver King, has produced, supplying rip-rap for local use.

The limestone is of good quality, averaging 95.7 and 93.8 percent $CaCO_3$, respectively, at the two properties. The material is suitable as flux for smelters, and for use in glass making, sugar-beet refining, and paper making, as well as for rip-rap.

However, other limestone sources are closer to markets, and deposits in the Palisades area are useful only for local needs (Benham, 1983).

Crushed and broken limestone is readily available in large volumes from the rock avalanche deposit along Blowout Canyon.

Sand and Gravel

Sand and gravel deposits are abundant along most margins of, and just outside of, the Palisades area. The largest deposits are in alluvium and adjoining terraces along the Snake River and its principal tributaries, and also in moderately well sorted, poorly indurated sandstone and conglomerate within the Tertiary volcaniclastics and conglomerate (Tvc). Gravel from the Tertiary unit was used by the Bureau of Reclamation to construct the Palisades dam. Sand and gravel supplies far exceed projected local needs; deposits along the major roads outside the Palisades area are more than adequate.

Metals

Despite the presence of significant geochemical anomalies, described above and by Antweiler and others (1984), the data are inadequate to ascertain with assurance the resource potential for metals detected; the potential is probably low. Stratabound metal deposits in the Nugget Sandstone are low grade, small, and discontinuous. Although the intrusives at and near Indian Peak, together with associated mineralized rock, may represent the top of a porphyry system, the low conodont CAIs for nearby strata and the absence of significant gravity or magnetic anomalies imply that no large intrusive mass is present at moderately shallow depths. The Indian Peak area is less intensely mineralized than the Caribou Mountain stock, which is composed of similar rocks (Huntsman, 1977; 1984), about 24 mi west-southwest. Vanadium and associated metals in the Phosphoria Formation could probably be recovered profitably, but only as byproducts of phosphate mining.

Geothermal

Heat-flow data are not available for the Palisades area but thermal phenomena are known at nearby localities. The area lies close to the Eastern Snake River Plain and Yellowstone Park thermal anomaly, characterized by high heat flow (Blackwell, 1978, p. 190). Warm springs occur in Swan Valley (Idaho Department of Water Resources, 1980), at Auburn Hot Springs south of Alpine and at Heise Hot Springs north of the area, at Astoria Hot Springs on the east, and along the Teton fault to the north. Large volumes of very hot water and CO_2 were encountered in two petroleum tests drilled at Big Elk Mountain, 7 mi west of the Palisades Reservoir, according to unpublished industry reports. Although a geothermal resource is unproved in the Palisades area, such a resource is possible but the potential is low.

SUGGESTIONS FOR FURTHER STUDIES

Needed most to define more precisely the Palisades resource potential are subsurface data from reflection seismic surveys and from exploratory drilling. The Palisades area has been investigated by several petroleum and geophysical companies, using helicopter-supported reflection seismic surveys, but this information is proprietary. The detailed geometry of subsurface structures favorable for the entrapment of oil and gas can be defined by helicopter-supported geophysical investigations with less environmental impact than by deep drilling. However, structural and stratigraphic traps defined by such methods can be tested only by exploratory deep drilling.

Detailed geochemical surveys would define better the areal distributions of anomalies found in our investigations. Geophysical surveys and exploratory drilling would also be useful in ascertaining whether metalliferous mineral resources are present.

ACKNOWLEDGMENTS

Critical reviews by Frank S. Simons, Vera H. Sable, and Richard B. Powers improved this manuscript and are gratefully acknowledged.

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