UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Mineral Resource Potential of the Sheep Mountain Wilderness, Albany County, Wyoming

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This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature.

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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 presently 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 Sheep Mountain Wilderness, Medicine Bow National Forest, Albany County, Wyoming. The area was established as a wilderness by Public Law 94-557 in October 1973.

MINERAL RESOURCE POTENTIAL SUMMARY STATEMENT

The Sheep Mountain Wilderness has low potential for mineral resources, and a low potential for petroleum at its eastern margin. The area contains rock, sand, and gravel resources useful for construction materials but much larger deposits can be found in many easily accessible places outside the wilderness boundaries.

The geologic terrane is not favorable for geothermal resources.

The Precambrian crystalline rocks of the core of Sheep Mountain consist of metasedimentary and metavolcanic rocks that are intruded by the Sherman Granite, which underlies about three-fourths of the study area. Minor quantities of copper are present in skarn along faults at the contact between the Sherman Granite and metavolcanic rocks, and at contacts between Sherman Granite and inclusions of mafic igneous rock. Quantities are small and do not constitute a potential resource.

A fossil beach placer containing heavy minerals, such as iron-titanium oxides, zircon, and monazite, is present in sedimentary rocks of Late Cretaceous age on the northeast margin of Sheep Mountain. This deposit is small and lies mostly outside the wilderness. Uranium in significant amounts was not detected in any of the rocks of the wilderness; uranium is present in very small quantities, 0.01 percent or less, in the fossil beach placer.

Late Cretaceous sedimentary rocks that bear coal in other areas are exposed on the northeast and east margin of Sheep Mountain. Thin beds of carbonaceous shale are present in the sedimentary rocks, but no coal was detected at the surface.

Oil and gas fields are present within 3.5 mi of Sheep Mountain. The best possibility for hydrocarbon accumulation in the Sheep Mountain Wilderness is in fault and (or) anticlinal traps developed as a result of thrusting near the east margin of the mountain. A rather speculative interpretation based on the limited surface exposures of sedimentary rocks located on the northeastern margin of Sheep Mountain indicates that a small anticline may be developed between the two westernmost thrust faults. If this interpretation is correct, the anticline may form a structural trap for oil and gas, but available data do not prove this kind of trap for the Sheep Mountain area.

INTRODUCTION

A mineral survey of the Sheep Mountain Wilderness, Albany County, Wyo., was made in 1975 and 1976 by the U.S. Bureau of Mines and U.S. Geological Survey. The wilderness encompasses approximately 15,000 acres (23 sq mi), mostly on Sheep Mountain, an isolated spur of the Medicine Bow Range. Sheep Mountain rises abruptly from adjoining valleys and is entirely within the Medicine Bow National Forest. The total relief is 2,100 ft. The highest point, 9,500 ft (location A, fig. 1), and the lowest point, 7,400 ft, are located along the east boundary of the area. Sheep Mountain is drained by a number of small streams that radiate from the mountain proper. The most important are Buckeye Creek and Hecht Creek, which drain the west margin of the mountain and flow into the Little Laramie River; Dale Creek and Fence Creek that drain the southern part of the mountain and flow into a tributary of the Laramie River, and John's Creek, Chokecherry Creek, and Hansen Creek, which drain the east margin of the mountain and flow into Lake Hattie.

The area is easily accessible from paved roads that are only a few miles from the area boundary. At present, access is restricted by private property owners, but a good access trail is located on National Forest land at the confluence of Fence Creek and Lake Owen Creek, about 2 mi from the southern boundary of the area.

PREVIOUS STUDIES

Previous geologic investigations in the Medicine Bow Mountains have been summarized by Houston and others (1968, p. 6-8). Geologic studies conducted in the area as part of a general survey of the Medicine Bow Mountains were sponsored by the Geological Survey of Wyoming in 1957-64 (Houston and others, 1968). Additional studies were part of the study of the Lake Owen quadrangle for the U.S. Geological Survey in 1970-71 (Houston and Orback, 1976). The first geologic map that included the Sheep Mountain area was U.S. Geological Survey Geologic Atlas 173, which covered the eastern part of Sheep Mountain (Darton and others, 1910). The area is also on the geologic map (1:63,360) that accompanies the report by Houston and others (1968).

The authors are not aware of any published or unpublished report that describes the mines and prospects of the Sheep Mountain area, despite the fact that several mines were in operation over a period of years.

PRESENT STUDIES AND ACKNOWLEDGMENTS

The present studies undertaken by the U.S. Geological Survey were conducted in July and August 1975 for the purpose of evaluating the mineral potential of the Sheep Mountain area and included geologic mapping, geochemical sampling, and evaluation of an aeromagnetic survey made in 1970. Daniel W. Worrall and Philip R. Vanderpoel assisted in the geologic mapping.

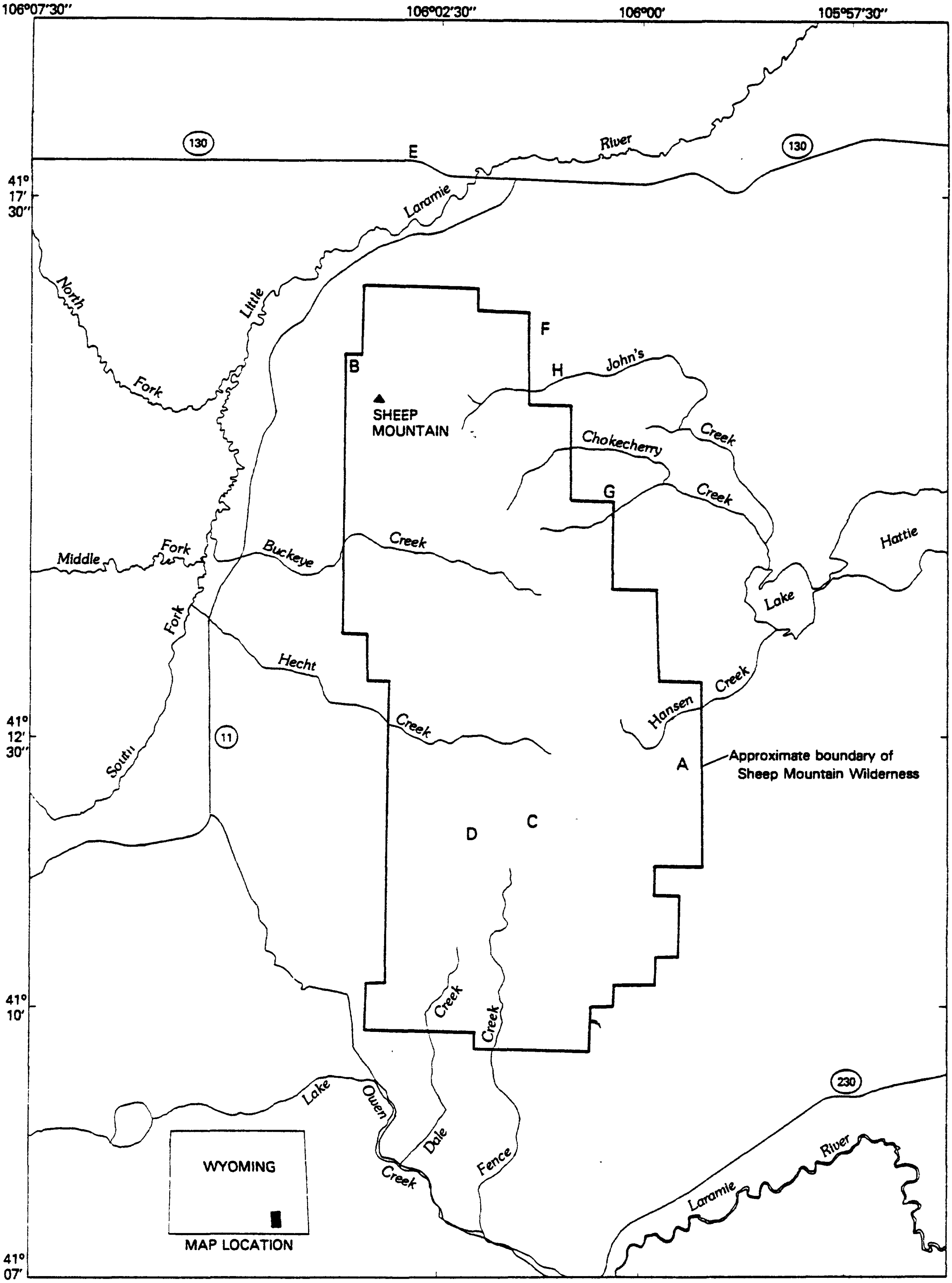

Figure 1.--Map showing location of the Sheep Mountain Wilderness, Wyoming. Lettered areas: A, highest point in study area; B, positive magnetic anomaly; C, magnetic ridge or nose; D, copper deposit; E, nose of fold; F, G, extent of fold axis; H, shale exposure. Lettered localities are discussed in text.

Foot traverses were made throughout the Sheep Mountain area to collect rock and stream-sediment samples and to supplement geologic mapping on a scale of 1:48,000. Some mapping was done outside the wilderness in order to better evaluate the potential for oil and gas, and to examine fossil marine placers located at the northeast boundary of the area. In addition, a ground radiometric survey was made of the southern half of the Sheep Mountain area to evaluate the potential of the Sherman Granite and its contact zone for thorium and uranium resources. Skarn zones near the northern contact of the Sherman Granite were inspected at night by use of short-wave ultraviolet radiation in attempts to detect the tungsten mineral scheelite. No radioactive anomalies were found and scheelite was not detected.

U.S. Bureau of Mines investigations of mining claims and mineralized areas were made during 1975 and 1976 by Lowell L. Patten and Joseph Gersic and included examination and sampling of old mine and prosepct workings and other areas that showed indications of mineral occurrences. The aid and cooperation of ranchers of the Sheep Mountain area, especially Everett E. Johnson, is gratefully acknowledged.

GEOLOGY

Sheep Mountain is a relatively small block uplifted during Laramide time and is connected at its southern extremity to the main mass of the Medicine Bow Mountain uplift (fig. 2). The Sheep Mountain block has the form of a north-plunging anticline, overturned and thrust eastward along one major and several minor west-dipping thrust faults (fig. 2).

The crystalline core of Sheep Mountain consists of rocks of Precambrian age. Older Precambrian rocks, which probably are around 1,800-1,900 m.y. old, consist of mafic and felsic gneisses and schists that have been metamorphosed to the amphibolite facies of regional metamorphism. The mafic units are largely hornblende gneiss and amphibolite; whereas, the felsic gneisses are largely biotite-quartz-plagioclase gneiss and granite gneiss. Siliceous marble and calc-schist are present but are uncommon. These rocks were intruded by a variety of igneous rocks that are themselves deformed and metamorphosed. Metabasalt, metagabbro, and metaperidotite were intruded early, and probably were affected by most of the metamorphic events. All of the above units are cut by quartz diorite, foliated granite, aplite gneiss, and pegmatite, all of which are approximately 1,700 m.y. old. These felsic igneous rocks are also strongly metamorphosed and exhibit a well-developed metamorphic foliation that conforms in strike to that of other metamorphic rocks. The metamorphic rocks just described crop out in the northern and southern part of the Sheep Mountain uplift (fig. 2).

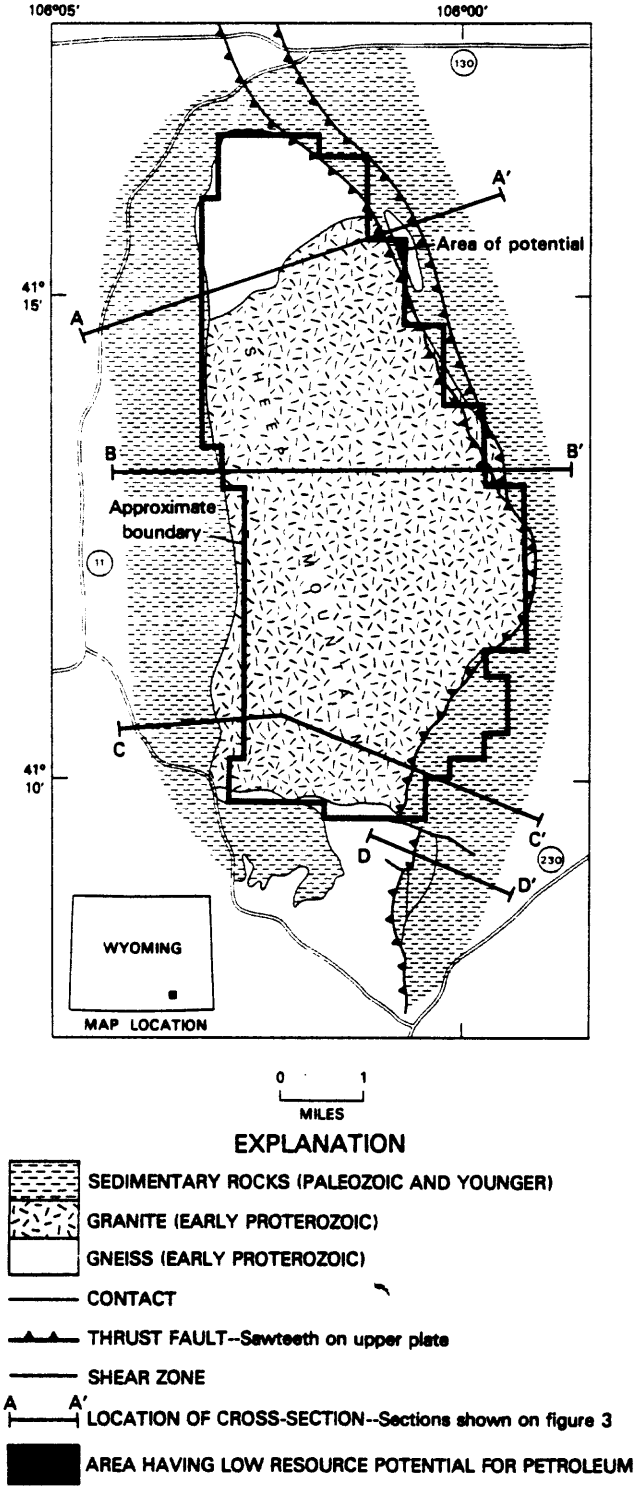

Figure 2.--Simplified geologic map showing locations of cross-sections and area of resource potential in the Sheep Mountain Wilderness, Wyo.

The entire central part of the Sheep Mountain uplift is underlain by the Sherman Granite which, with the possible exception of some satellite pegmatites and dikes, is the youngest rock of Precambrian age in the area. The Sherman Granite is about 1,400 m.y. old and is clearly intrusive into all other rocks of Precambrian age. In the Sheep Mountain area, the Sherman Granite has two major facies, a pink, medium-grained facies more common near contacts and a younger coarse-grained porphyritic facies. The Sherman Granite has two zones as much as 450 ft wide and 4,000 ft long containing numerous inclusions of mafic rock (probably amphibolitized basalt); elsewhere stretched and flattened inclusions of mafic rock are common but are nowhere abundant. These flattened inclusions are usually oriented parallel to the plane of foliation in the granite and their long dimension plunges vertically. The foliation of the Sherman Granite strikes roughly east-west and is steeply dipping. The strike of foliation is not parallel to that of older rocks except near contacts. The overall characteristics of the Sherman Granite indicate that it is a post-tectonic granite probably emplaced by forcible injection and stoping into older rocks.

Paleozoic and Mesozoic sedimentary rocks are present on the west, north, and east margins of Sheep Mountain (fig. 2). These sedimentary rocks are platform-type, mostly sandstone, shale, and limestone deposited in shallow seas (table 1). The sedimentary succession is about 10,000 ft thick. The Paleozoic and Mesozoic sedimentary succession is best exposed on the west flank of Sheep Mountain where beds dip about 45° W.; to the north and east Paleozoic and Mesozoic sedimentary rocks are largely covered by nonmarine Tertiary rocks of probable Miocene age and by Quaternary colluvium landslide debris and pediment gravel.

The Sheep Mountain area has had a long and complex structural history beginning with deformation that perhaps accompanied and followed sedimentation and volcanism during Precambrian time. This event was a regional episode accompanied by metamorphism and the formation of felsic bodies such as quartz diorite and granite pegmatite. It resulted in the development of an east-northeast-striking structural pattern that is characteristic of the metamorphic rocks of Precambrian age in southeastern Wyoming and northern Colorado. The exact timing of this event is unknown but it probably took place around 1,800 m.y. ago (Peterman and others, 1968). Recent geologic interpretation suggests that island arcs resembling modern day Japan were attached to an older shield of central Wyoming at about this time (Hills and Houston, 1979).

The regional east-northeast structure is deflected in the southern part of the Sheep Mountain area where metamorphic planar structure strikes generally more northeast; minor folds that developed during deformation and metamorphism plunge southwest. This change in structure is probably related to the emplacement of the Lake Owen Mafic Complex, located 1 mi west of the Sheep Mountain map area (Houston and others, 1968, pl. 1). The structure was also modified by the intrusion of the Sherman Granite as much as 1 mi from the granite contact. This is clearly shown at the southern margin of the granite where planar structures are deflected so that they are oriented parallel to the contact of the granite, where shearing is common, and where earlier fold systems are refolded (fig. 2; Houston and Orback, 1976).

The Precambrian structure at the north end of Sheep Mountain also appears to diverge from the general east-northeast trend but the west-northwest-striking planar structure of this area is probably the north limb of a large east-northeast-plunging fold located in the south-central Medicine Bow Mountains (Houston and others, 1968, pl. 1). The structure of the host metamorphic rocks is also modified by the Sherman Granite in the northern part of the mountains but the area affected is less than 1,300 ft from the granite contact.

The Precambrian structural history is much more complex than suggested above, as shown by abundant evidence of multiple deformation and a long igneous history (Houston and others, 1968, p. 139-146) but this brief summary describes the major structural features.

West of Sheep Mountain, in the south-central Medicine Bow Mountains, a series of northwest-striking faults developed during Precambrian time after emplacement of the Sherman Granite. Many of these faults are mineralized and it is this mineralized fault system that accounts for the late 19th to early 20th century mining districts established in this general area (Currey, 1965). Prospecting activity during this period extended into the Sheep Mountain area, but no mineral deposits comparable to those of the south-central Medicine Bow Mountains were found.

Fracture systems of Precambrian age are common in the Sheep Mountain area, but few of these are large enough to be mapped at a scale of 1:48,000, and most mapped fractures were reactivated during the Laramide (Rocky Mountain) orogeny so their Precambrian ancestry is uncertain. The most significant fault in the southern part of the area is an east-striking shear zone located 450 ft south of the contact of gneisses with the Sherman Granite (fig. 2). This shear zone was reactivated during the Laramide orogeny. Many small shear zones parallel this fault in the area of the granite contact, and some of these are mineralized. Other faults at the southeast margin of the Sheep Mountain area, located on the hanging wall of the major thrust fault, are of questionable Precambrian age.

A number of north-striking fractures in the Sherman Granite are filled with fine-grained granite and aplite, and several northeast-striking faults filled with quartz and epidote were noted. None of these fractures are mineralized.

During the Laramide orogeny (an episode of deformation that began in this area in latest Cretaceous and extended into early Eocene (Knight, 1953; Houston and others, 1968, p. 95-100)), Sheep Mountain was uplifted. Major thrust faults developed on the foreland during the orogeny, and the Medicine Bow Mountains are an example of a major compound uplift that formed during this episode (Houston and others, 1968, pl. 34). In Wyoming, foreland folds or uplifts resemble large asymmetric anticlines that are usually marked by major thrust faults on the overturned limb. These major uplifts are separated by basins that have a much greater area than the uplift proper and are filled with a sequence of sedimentary rocks. A typical major uplift is usually flanked by minor folds or uplifts that are concentrated at the margin of the uplift and are less well developed or nonexistent near the center of the basin. Most major uplifts have cores of Precambrian rocks and most minor uplifts are far enough from the edge of the major basins to be covered with sedimentary rocks of Paleozoic and Mesozoic age.

Sheep Mountain is part of the main frontal uplift of the Medicine Bow Mountains. The thrust fault on the east margin of Sheep Mountain lies along the trend of a primary thrust, the Arlington thrust fault, located in the northeast part of the Medicine Bow Mountains.

As shown in the cross sections (fig. 3), the main thrust fault on the east margin of Sheep Mountain, called the Sheep Mountain fault by Beckwith (1938, pl. 1), has a stratigraphic displacement of greater than 9,400 ft at the east-central margin of Sheep Mountain (fig. 3, sec. B-B'). Stratigraphic displacement decreases both north (fig. 3, cross sec. A-A') and south (fig. 3, cross sec. C-C') on the main fault. Rock exposures are so poor in the east margin of Sheep Mountain that it is difficult to document the exact number of faults, but it is clear that several minor thrust faults developed east of the main Sheep Mountain thrust. These minor thrust faults may extend to the basement (Precambrian crystalline rocks) or they may be entirely within the sedimentary succession and therefore detached from the basement, or in some cases, they may be segments of major slide blocks (Houston and Orback, 1976, sec. C-C').

GEOPHYSICAL INVESTIGATIONS

An aeromagnetic survey was made of the Sheep Mountain area by the U.S. Geological Survey in 1970 (Ketterer, 1976). The aeromagnetic survey was flown at a constant altitude of 11,800 ft above sea level and at a flight-line spacing of 1 mi. This survey has been used to assist the assessment of mineral resource potential of the area, and has been interpreted with the assistance of M. D. Kleinkopf.

A positive magnetic anomaly exists at location B (fig. 1) near the contact between the Fountain Formation, Precambrian granite, and metasedimentary rocks. The anomaly must be the expression of a buried feature because none of the surface rocks contain appreciable magnetite or other magnetic minerals. It is possible that this positive closure may represent a buried intrusion, but the significance of such an intrusion in terms of mineralization cannot be evaluated.

A northeast-striking magnetic ridge or nose is found at location C (fig. 1). This ridge is probably a residual anomaly associated with a northeast-striking swarm of mafic inclusions in the Sherman Granite.

The steep magnetic gradient in the southwest part of the map area is part of a major dipole anomaly associated with the Lake Owen mafic complex, a large layered complex rich in magnetite and cropping out outside the wilderness (Houston and Orback, 1976). This dipole anomaly is shown on a map by Ketterer (1976); and Wood and Kaufmann (1977) compared ground magnetic values of vertical, horizontal, and total-field intensity with airborne total-field measurements.

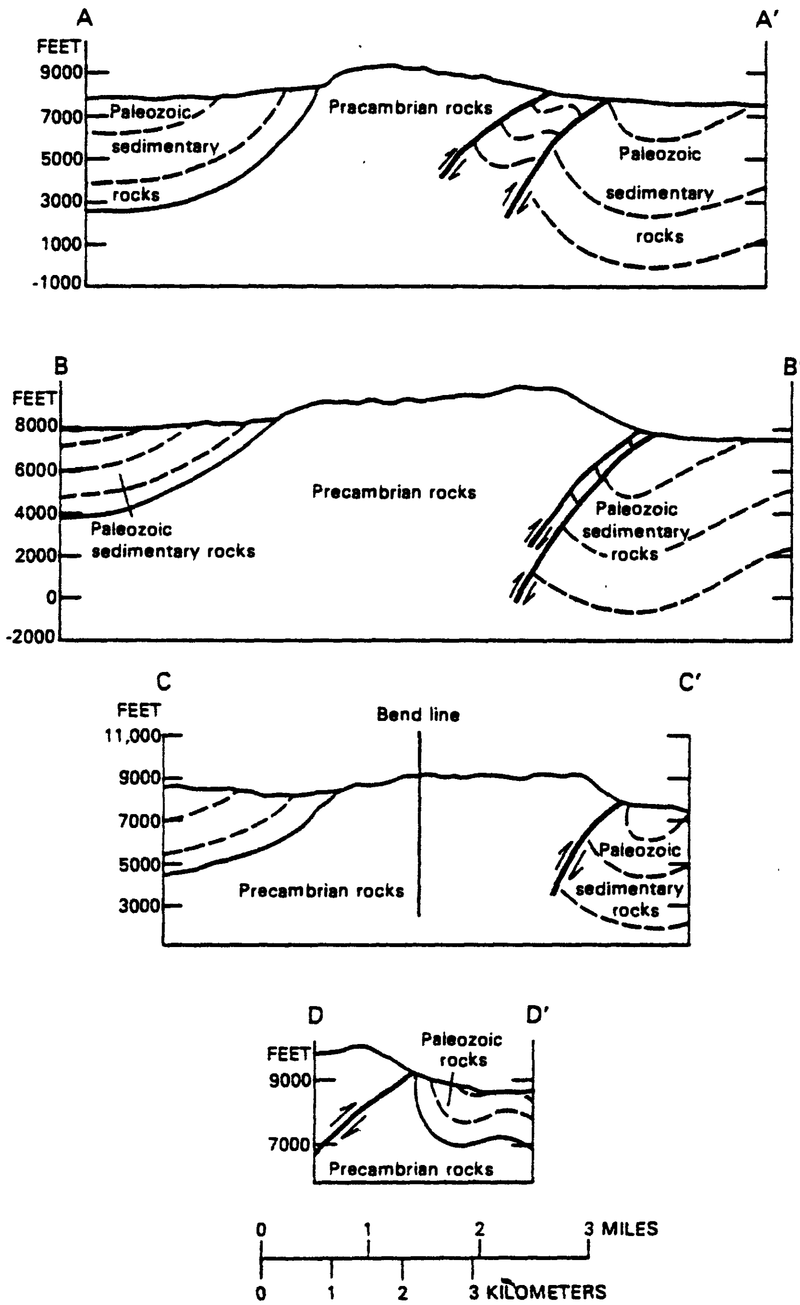

Figure 3.--Cross-sections from the Sheep Mountain Wilderness, Wyo. Lines of sections shown on figure 2. Dashed lines indicate orientation of sedimentary rocks.

In general, the elevation and flight-line spacing of the aeromagnetic survey are such that the data cannot be used to support arguments for or against significant mineral potential in this area.

GEOCHEMICAL SURVEY

A geochemical survey was undertaken in the Sheep Mountain area to supplement geologic and geophysical surveys. One hundred forty-four samples were collected, of which 97 are rock samples and 47 are stream-sediment samples. Rock samples having no visible indication of valuable minerals were collected to determine the normal concentrations of selected elements in the country rock. Stream-sediment samples were collected so that approximately one sample site was located in each square mile segment. Samples were also collected at the confluence with tributary streams and where streams from Sheep Mountain change gradient at the mountain front.

All samples were analyzed for 30 elements by a semiquantitative six-step emission spectrographic method (Grimes and Marranzino, 1968) in the U.S. Geological Survey laboratories, Denver, by Leon A. Bradley. The samples were also analyzed for copper and gold by atomic-absorption spectroscopy in the U.S. Geological Survey laboratories, Denver, by Jim Crock, A. E. Haubert, and Claude Hauffman, Jr. In addition, all stream-sediment samples were analyzed by a 0.8N nitric acid leach atomic-absorption method for extractable copper.

Although some samples were considered to contain anomalous amounts of metals, none of these anomalous values could be associated with known or potential mineral deposits. Most metal concentrations were from mines, prospects, or mineralized areas.

MINING ACTIVITY

No organized mining district is within the study area, and there is no current mining or prospecting activity in the Sheep Mountain area. Twenty-eight mining claims have been located wholly or partly within the wilderness and 82 other claims are within 2 mi of the area boundary. These claims were located on four types of structures:

1. Narrow and discontinuous quartz veins and local skarns at the northern contact between Sherman Granite and older metamorphic rocks
2. Quartz veins and veinlets in fractured Sherman Granite; especially where swarms of mafic inclusions are present
3. Small quartz veins and fractures in metamorphic rocks south of the study area
4. Beds of titaniferous black sandstone of the Mesaverde Formation at the northeast border of the map area.

The surface mineralization at prospects extends only for short distances, and there is no record of mineral production from any mine or prospect in or adjacent to the Sheep Mountain area.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

Metallic mineral deposits

The sulfide mineralization in quartz veinlets and in discontinuous fractures in the Sherman Granite is not extensive at the surface and geologic reasoning suggests the mineralization does not extend to greater depth. Granites and related felsic intrusions may have mineral deposits in or near them that are either deposited from solutions that escape from the crystallizing granite or from hot water systems that circulate in and adjacent to the hot crystallizing magma. In general, mineral deposits tend to be found in association with granitic intrusions that were emplaced at shallow depth and that have not been deeply eroded. The Sherman Granite fails both of these tests; the weight of the geologic evidence is that it crystallized at too great a depth, and that it has been deeply eroded since emplacement (see Eggler, 1968, for a discussion of criteria for depth of emplacement and depth of erosion for the Sherman Granite). The Sherman Granite was emplaced some 500 m.y. after deposition of volcanic rocks of this area and as part of a magmatic event that affected a broad zone extending from Labrador to California (Silver and others, 1977). At present, there is no good geologic model to explain the origin of granites of this period, and it is therefore difficult to determine the types of mineral deposits, if any, that might be associated with them. The Sherman Granite at Sheep Mountain is part of a major granite batholith that underlies a large area in southeastern Wyoming and northern Colorado (Houston and others, 1968, fig. 25). With the exception of pegmatite, no mineral deposits are known to be associated with this batholith. The most promising prospects having known copper occurrences are in the Silver Crown mining district of Laramie County, Wyo. (Klein, 1974). The mineral deposits of the Silver Crown mining district are in faults and shear zones in a foliated granodiorite that is in contact with the Sherman Granite, somewhat like the deposits at the south end of Sheep Mountain. The Silver Crown deposits were mined at the turn of the century and have been examined by a number of mining company geologists in the last three decades. From 1938 to 1972, 32 holes were drilled in the area with a total footage of 13,127 ft (Klein, 1974, table 1) without finding deposits of economic value.

Most other copper occurrences in the Sherman Granite are associated with dikes or inclusions of mafic rock and are like occurrences found at locality D (fig. 1). The copper probably came from the mafic bodies as a late-stage differentiate or was mobilized from the mafic inclusions during emplacement of the Sherman Granite. It is doubtful that significant copper deposits could form in this manner. The area underlain by the granitic rocks of the Sheep Mountain area has a low potential for metallic resources.

The metasedimentary-metavolcanic rock succession of Sheep Mountain was probably deposited in an island arc setting much like modern-day Japan, some 1,900 m.y. ago. The most typical mineral deposits in island-arc rock successions are referred to as volcanogenic; the mineralization occurs in association with volcanic rocks that generally are the final products of an extensive episode of volcanism. No volcanic rock successions of this type were identified in the Sheep Mountain area, although areas west and south of Sheep Mountain may be suitable for prospecting for deposits of this type.

Titaniferous black sandstone

Lenses of titaniferous black sandstone crop out along the northeast border of the Sheep Mountain area in the Pine Ridge member of the Mesaverde Sandstone, but so far as can be determined from limited surface exposures, the deposits are all outside the study area. These black sandstone layers are ancient beach placers probably deposited on the backshore of beaches during Cretaceous time.

Minerals of interest are iron-titanium oxides, zircon, monazite, and native gold. The deposits are described in some detail by Houston and Murphy (1962) who suggest that several factors limit their commercial value. The black sandstone occurrences on Sheep Mountain are not large. The exposed length is about 2,000 ft and maximum thickness about 15 ft. Unless there is greater tonnage at depth the deposits are not large enough to be of interest to mining concerns or companies. The iron-titanium oxides at Sheep Mountain are mixed minerals; that is, the magnetite is high in titanium and the ilmenite high in iron. Zircon, monazite, and native gold are all present in the black sandstone in the Sheep Mountain area and might be recovered as a by-product of mining of iron-titanium oxides, but they are not abundant enough to be mineable by themselves. We suggest, however, that with the limited sampling that has been done and with the sampling difficulties involved in testing for gold (Clifton and others, 1969), the actual gold content of these sandstone layers remains uncertain.

Oil and gas resources

Oil and gas accumulations are known in many of the small anticlines east of the Arlington fault on the east margin of the Medicine Bow Mountains (Glass and others, 1975). The Rex Lake oil field is located approximately 3.5 mi northeast of Sheep Mountain and the Big Hollow oil field about 7 mi east of Sheep Mountain. Both of these fields are structural traps where petroleum and natural gas are localized in the crests of anticlines. No stratigraphic traps have been found in the Laramie basin east of Sheep Mountain, but inasmuch as all anticlines that are theoretically favorable traps do not have accumulations of oil or gas, it has been suggested that some traps that appear to be anticlinal are actually combined structural-stratigraphic traps (Stone, 1966).

In the Sheep Mountain area there are probably only two types of petroleum and natural gas traps, a fault trap on the footwall of the main thrust or an anticlinal trap developed either through crowding between thrusts or by some type of basement deformation under the thrust sheet. Section D-D' (fig. 3) is an interpretation of surface exposures that requires tight folding or differential shearing of the crystalline basement and the development of a type of structure that, if deeply buried, might constitute a structural trap. Other interpretations, which do not require basement folding, can be made from these surface exposures; however, this type of basement folding is fully exposed in other parts of the Medicine Bow Mountains (Houston and others, 1968). At the north end of Sheep Mountain a somewhat similar structure may be present (fig. 3, sec. A-A').

Section A-A' (fig. 3) is taken from Blackstone (1970, pl. 1, sec. D-D') and shows two high-angle reverse faults with accompanying folds in the sedimentary succession. The most interesting structure is the anticline that developed between the two reverse faults. The northwest nose of this fold is shown on Blackstone's map (1970, pl. 1) in secs. 4 and 5, T. 15 N., R. 77 W., and as location E in figure 1. If this interpretation is correct, the crest of the fold where petroleum traps might exist would be located southeast of this point somewhere along the east flank of Sheep Mountain. Blackstone (1970, pl. 1) showed this fold axis extending southeast to sec. 15, T. 15 N., R. 77 W. (location F, fig. 1) where he believed it is cut out by thrust faults. This may be a sound interpretation, but exposures on the east side of Sheep Mountain permit other interpretations. Figure 3 (sec. A-A') shows the fold continuing farther southeast where it is wedged between two thrust faults and overturned; the fold then continues to sec. 25, T. 15 N., R. 77 W. (location G, fig. 1). This interpretation is dependent on the classification of poorly exposed shales at location H (fig. 1) as part of the Frontier Formation. We consider part of the shale section to be Frontier Formation; Blackstone considered it to be entirely Steele Shale. Either of these interpretations is possible but the Frontier Formation interpretation is used in this report so that the question of a possible petroleum trap can be considered. In figure 3 (sec. A-A'), this fold is shown to be largely developed in the sedimentary succession without a tight basement flexure as shown in section D-D' (fig. 3), but the basement may have been involved. This is a highly speculative interpretation based on very limited surface exposures, but it presents the possibility of the most favorable locality in this area for oil and gas accumulation. The boundary of the Sheep Mountain Wilderness as currently designated excludes most, but not all of this structure.

A second and less likely possibility for a petroleum trap is a fault trap beneath the Sheep Mountain thrust fault. If the faults are an early part of the deformation, oil and gas can migrate up dip in reservoir beds and be trapped beneath the hanging wall of the thrust fault. This requires that the rock on the hanging wall be impermeable, which is probably not the case if the hanging wall rock is fractured Precambrian crystalline rocks, but might be the case if thrust faults in the sedimentary succession bring an impermeable shale over a foot-wall reservoir rock. Inasmuch as the latter is almost impossible to evaluate using the limited outcrop on the east side of Sheep Mountain, a trap would probably have to be considered on the hanging wall of the main Sheep Mountain fault where Sherman Granite would be brought into contact with reservoir rocks. Deformed Sherman Granite would probably not be impermeable and no trap would form.

The geologic and geophysical investigations do not demonstrate that petroleum traps are present in the Sheep Mountain area, but possibilities exist. For example, as shown in section A-A' (fig. 3), several thrust faults juxtapose impermeable formations above possible reservoir rocks. Section B-B' (fig. 3) may be an oversimplification; more thrusts may exist than are shown and thus afford possibilities for structural traps. Exploratory drilling and (or) seismic investigations are required if these possibilities are to be tested.

An important consideration in exploration for oil and gas in faulted areas is the angle of inclination of the faults. Thrust faults that border Laramide uplifts have been interpreted as steeply inclined by geologists who prefer vertical uplift as the mechanism of development of such structures as

Sheep Mountain. Geologists who prefer horizontal compression as the mechanism for development of these structures interpret the faults as gently inclined. Until recently, geophysical investigations, such as deep seismic profiling, necessary to define the angle of inclination of faults bounding Laramide uplifts were not reported in the literature, but a seismic study of the fault system on the west flank of the Wind River uplift of northwestern Wyoming has shown that these faults have a dip of about 30^{o} and may extend to the mantle (Smithson and others, 1978).

The dip of thrust faults located on the southeastern margin of Sheep Mountain is 35^{o}-40^{o} W. If low dips of this type extend to great depths, a much more extensive section of sedimentary rocks might underlie Sheep Mountain than is indicated by the cross sections. This might increase the possibilities for oil and gas accumulation, but such determinations regarding fault inclination would require expensive deep seismic profiles.

Summary

The resource potential of the Sheep Mountain Wilderness is low for metallic and nonmetallic minerals. There is a remote possibility that structural traps for oil and gas may be present on the eastern margin of Sheep Mountain. The potential for oil and gas depends to a large extent on the dip of thrust faults that are on the east margin of the Sheep Mountain uplift. If these thrust faults are low angle (less than 30^{o}), then oil and gas potential is greater. However, based on our present knowledge the potential for oil and gas resources is low.

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Table 1.--Generalized stratigraphic section of the Sheep Mountain Wilderness, Wyo.

[Thickness given in feet; to convert to meters multiply feet by 0.3048. Leaders (---) indicate no data]

System	Series	Formation	Thickness (in feet)	Description
Quaternary-----	Holocene--	Alluvial, landslide, pediment gravels, and colluvium deposits.	0-100	Clay, silt, sand, and and gravel along streams; gravel, sand, and silt on pediment surfaces; and gravel, sand, silt mixed with large coherent rock masses in landslides. Colluvium consists of slope wash aprons and masses of granite gravel.
		Unconformity		
Tertiary-------	Miocene---	North Park Formation and Brown's Park Formation undivided.	0-300	White to gray, medium- to coarse-grained sandstone and arkose. Succession contains beds of conglomerate and conglomeratic sandstone, clasts of which consist chiefly of locally derived pebbles and cobbles of Precambrian rocks.
		Unconformity		
Cretaceous-----	Upper-----	Lewis Shale---	2,400-3,000	Gray to brownish-gray, thick, interbedded, fine-grained sandstone; zones of ironstone concretions near middle.
Do-------------	--do----	Pine Ridge Sandstone (Mesa Verde Group).	310	Pale-yellowish, very fine to fine-grained sandstone; locally contains beds of black heavy minerals.
Do-------------	--do----	Rock River Formation.	1,100	Light-gray to light-brown, soft sandstone and sandy shale.
Do-------------	--do----	Steele Shale--	2,700	Dark-gray shale and thin beds of brown sandstone.

Table 1.--Generalized stratigraphic section of the Sheep Mountain Wilderness, Wyo.--Continued

System	Series	Formation	Thickness (in feet)	Description
Cretaceous-----	--do----	Niobrara Formation.	800	Dark-gray shale containing 3 or 4 beds of shaly chalk in upper part. Highly fossiliferous, containing diversified foraminiferal fauna and abundant mollusks, including the large, thick-shelled pelecypod, Inoceramus platinus, and oyster Pseudoperna congesta. Some thin beds in upper part consist almost entirely of oyster shells.
Do-------------	--do----	Frontier Formation.	650	Mostly dark-gray to black shale containing bentonite beds and siderite septarian concretions, especially near base. Wall Creek Sandstone Member, at top, has as many as 3 thin, discontinuous beds of salt-and-pepper sandstone containing black chert grains and commonly shark and ray teeth.
Do-------------	Lower---	Mowry Shale---	165	Dark-gray to black siliceous shale containing thin beds of bentonite. Siliceous shale weathers to silvery gray and supports very little vegetation.
Do-------------	--do----	Thermopolis Shale.	100	Underlain by black shale and thin layers of brown, fine-grained sandstone.
Do-------------	--do----	Cloverly Formation.	130	Upper beds consist of upper reddish-brown, iron-stained, thin-bedded sandstone; middle pink shale and gray to pink siltstone; and basal, white, crossbedded, locally conglomeratic sandstone.
		Unconformity		
Jurassic-------	Upper-----	Morrison Formation.	300	Lower beds characterized bluish-gray to purple to deep-red to gray shales that contain lenticular beds of white, fine-grained, crossbedded sandstone and gray, nodular limestone.

Table 1.--Generalized stratigraphic section of the Sheep Mountain Wilderness, Wyo.--Continued

System	Series	Formation	Thickness (in feet)	Description
Do-------------	Upper and middle.	Sundance Formation.	75	White, crossbedded and ripple-marked, calcareous, glauconitic sandstone, green shale, red to white shaly sandstone, and red to orange siltstones.
		Unconformity		
Triassic-------	Upper------	Jelm Formation.	250	Orange and red siltstone and sandstone and underlying distinctive clay-pebble conglomerate.
Do-------------	Lower------	Red Peak Formation.	700	Mostly red shale and red silstone containing local thin beds of calcareous sandstone.
Permian--------	----	Goose Egg-----	130	Red sandstone containing beds of gray to white limestone and gypsum.
Permian and Pennsylvanian.	Lower and Upper.	Casper Formation.	208	Threefold unit composed of upper sandstone, middle shale, and basal sandstone. Sandstone pink, buff, or white, medium to fine grained, generally calcareous; well-developed festoon crossbedding; some medium-grained sandstone contains abundant orange chert grains. Shale pink, red, and gray; may contain thin beds of gray limestone.
Pennsylvanian--	Upper and Middle.	Fountain Formation.	400	Mostly purple arkosic sandstone, but contains beds of light-purple arkose, gray sandstone, white limestone, red siltstone, red shale, gray conglomeratic sandstone and conglomerate. Beds discontinuous and variable in thickness; channels filled with crossbedded sandstone and (or) conglomerate are common.
		Unconformity		

Table 1.--Generalized stratigraphic section of the Sheep Mountain Wilderness, Wyo.--Continued

System	Series	Formation	Thickness (in feet)	Description
Proterozoic----	Middle----	Sherman Granite.	----	Pink, medium- to coarse-grained, faintly foliated granite; medium-grained facies more common near contacts and younger coarse-grained porphyritic facies. Exhibits sharp contacts with older rocks, Exhibits sharp contacts with older rocks, locally intruded by sills and dikes from the main granite body. Local hybridization of both granite (abundant amphibole and biotite) and country rock (abundant potash feldspar), especially where granite is in contact with mafic rocks. Stretched and flattened inclusions of amphibolite common but nowhere abundant. Locally sheared and brecciated zones rich in epidote and quartz. Dated by Rb/Sr whole-rock isochron at 1.35±30 m.y. (million years).
Do-------------	Lower-----	Aplite gneiss.	----	Pink to pinkish gray. Sills are most typical form of occurrence.
Do-------------	--do----	Foliated granite.	----	Pink to pinkish gray. Similar granite dated as 1,760± m.y.
Do-------------	--do--	Quartz diorite.	----	Light-pink to gray quartz diorite having wide variation in texture, structure, and mineralogy.
Do-------------	--do----	Metaperidotite	----	Greenish-black to purple schistose metaperidotite.
Do-------------	--do----	Mafic unit----	----	Complex unit composed of interlayered mafic rocks including hornblende gneiss, amphibolite, metagabbro, metabasalt, and also including lesser amounts of felsic rock such as biotite-quartz-plagioclase gneiss, biotite schist, quartz-rich gneiss, aplite gneiss, granite gneiss, granite, and pegmatite.
Do-------------	--do----	Felsic unit---	----	Mafic and felsic units as described above; also includes some interlayers of marble, calc-schist, and skarn.