THE GEOLOGICAL SURVEY OF WYOMING
GARY B. GLASS, STATE GEOLOGIST

GUIDE TO THE GEOLOGY, MINING DISTRICTS, AND GHOST TOWNS OF THE MEDICINE BOW MOUNTAINS AND SNOWY RANGE SCENIC BYWAY

BY

W. DAN HAUSEL

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1993

LARAMIE, WYOMING

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Front Cover: The historical Keystone gold mine and mill along Douglas Creek, circa 1905. About 5000 ounces of gold were recovered from quartz biotite schist at this mine between about 1876 and 1893. The shaft, located beneath the headframe (behind the cabin on the right side of the photograph), was about 365 feet deep and had about 5000 feet of tunnels. For more information on this area, see the discussion for **Locality 45**, pages 33 and 34. (Photograph from the University of Wyoming's American Heritage Center, S.H. Knight collection. Reproduced and printed with permission.)

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by
W. Dan Hausel

Laramie, Wyoming
1993

STATE OF WYOMING
1933
GEOLOGICAL SURVEY

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Preface

As a geologist with the Geological Survey of Wyoming, I have been fascinated with the historical mines, towns, and mining districts of the Medicine Bow Mountains. So when there were opportunities, I visited the historical mines and prospects to examine the geology, minerals, and mining artifacts; and where it was still possible to get underground, I spent some time mapping and sampling these mines. When the U.S. Forest Service established a portion of Wyoming Highway 130 as a Scenic Byway, it seemed natural to compile some of my notes and combine them with the published literature into a guide for use by tourists and recreational gold panners and prospectors.

This guide would not be complete without the assiduous geologic studies of the Medicine Bow Mountains and nearby Sierra Madre by Drs. Robert S. Houston, Paul J. Graff, and Karl E. Karlstrom. These three individuals greatly expanded our current knowledge of these ancient mountain ranges. In 1989, I was privileged to work with Dr. Houston in preparing a field conference for the International Geological Congress (Snyder and others, 1989), which involved geologists from all over the world including Africa, Canada, China, France, the Soviet Union, Spain, and the United States. During this conference, Dr. Houston led the attendees through some spectacular rock outcrops along the Snowy Range Scenic Byway which I've described in this guide.

For those who share common interests in the geological history, mining history, or prospecting and panning of the Medicine Bow Mountains, I welcome your interest. We at the Geological Survey of Wyoming look forward to talking with you or helping you identify any rocks or minerals you might collect on your visit. We are located in Laramie on the University of Wyoming campus.

Some readers may have questions about the rules and regulations that apply to recreational prospecting. Most of these questions can be answered by one of the following regulatory agencies:

(1) Information on mining claims-

U.S. Bureau of Land Management
P. O. Box 1828
Cheyenne, WY. 82003-1828
(307) 775-6256

(2) Information on land and road use-
U.S. Forest Service
2468 Jackson Street
Laramie. WY. 82070-6535
(307) 745-8971

(3) Rules and requirements for dredging-

Wyoming Department of Environmental Quality
Herschler Building
Cheyenne, WY. 82002
(307) 777-7756

Public lands in the Medicine Bow Mountains provide an opportunity for a wide variety of recreational and multiple uses. My wish is that this guide assists you in more fully enjoying these public lands and the scenic byway.

W. Dan Hausel
Laramie, Wyoming
September, 1993

Abstract

The Medicine Bow Mountains and the Snowy Range include a fascinating mining history that began in the early to mid 1800s. Hundreds of prospectors and miners were attracted to this region for gold, platinum, palladium, copper, rare earth metals, uranium, and more recently for diamonds. But like most high-risk mining ventures, most left as poor as they came, although a few were successful in their endeavors.

The geology of the Medicine Bow Mountains records more than two and a half billion years of geologic history. This history is contained in the rocks exposed throughout the mountains and is continually being unlocked and revealed by geologists.

Many interesting geological and mining history sites are described in this guide. These sites were selected to help the reader to more fully appreciate these mountains.

Introduction

Welcome to the Snowy Range and the Medicine Bow Mountains. These ancient mountains record more than 2.5 billion years of geologic history in their outcrops, peaks, and ridges. Rock successions similar to those found in the core of the Medicine Bow Mountains are quite rare on the surface of the earth today; only a few other places in the world, most notably in the Witwatersrand Basin of South Africa, contain similar rock successions.

The oldest rocks in the Medicine Bow Mountains are more than 2.5 billion years old. They are so old that they were formed long before any complex lifeforms developed on this planet. In fact, the oldest rocks crystallized long before the earth's atmosphere became sufficiently oxygen-rich to support any type of life other than the simplest plankton and algae.

These and younger rocks exposed in the Medicine Bow Mountains record many interesting geological events, such as 2.5 to 1.7 billion-year-old rivers and streams eroding millions of tons of sediment from a highland to the north and carrying the sediment to an ocean basin a relatively short distance to the south. South of the ancient coastline of this basin, about 2.0 to 1.8 billion years ago, island chains with active volcanoes erupted large volumes of ash and lava. Portions of the ancient sea floor were then subducted under the ancient continent forming a major suture (fault) between these two contrasting lands.

More recently in geologic history (only about 100 million years ago), a major mountain-forming event known as the Laramide Orogeny began. As a result, the Medicine Bow Mountains rose thousands of feet above the nearby basins. Even more recently, during the Pleistocene (1.6 million to 10,000 years ago), glaciers carved shallow basins in the hard quartzite of the Snowy Range, and left high alpine lakes in their wake.

During the history of man, the Medicine Bow Mountains were not only explored and hunted by Indians, but were also prospected by hundreds of individuals looking for riches that promised a better way of life, and could have provided relief from severe economic depressions. In their sojourns, gold fever inflicted many, and numerous tunnels and stream gravels were dug in the search of precious metal. Some individuals found gold, but most left as broke as they came, although much richer in experience.

In addition to gold, other metals were found in the Medicine Bow Mountains. In 1900, platinum and palladium were discovered and sporadically mined until 1918. The turn of the century brought higher copper prices, and many prospectors redirected their efforts to search for copper. By the end of the first decade, copper prices dropped and the search for the metal was suspended except by a few assiduous prospectors. In the 1930s, another economic depression drove men to this area to search for gold. Again, only a few left wealthy. In the late 1970s, a new valuable metal, uranium, was discovered in the Medicine Bow Mountains. This discovery led to a modern day rush. However, the uranium soon lost its value like many of the other metals found decades before. The 1977 discovery of diamonds in a gold placer in the northern Medicine Bow Mountains led to dreams of another rush, but these dreams quickly dissipated when further attempts to find more diamonds went unrewarded.

Although many of these mineral resources have lost their value in the past, in time, values change. Changing economic climates and reevaluation of geologic ideas, may cause some of these resources to increase in value and be sought by future prospectors. For we know that significant resources still remain in the hills as does a wealth of geologic history.

Acknowledgments

I would like to thank Dr. Paul J. Graff for reviewing this manuscript and providing me with critical comments and moral support. I would also like to thank Sheila Roberts for providing many of the photographs for the text and for her assistance in the outlining of the field trip.

Geologic setting

The Medicine Bow Mountains rise as high as 12,013 feet above sea level and the adjacent Laramie, Saratoga, and Hanna Basins lie at elevations of 6,000 to 8,000 feet. The higher peaks of the Snowy Range, which comprise the core of the Medicine Bow Mountains, are pock-marked by numerous lakes left behind by glaciers from the last ice age about 10,000 years ago. These glaciers also carved spectacular ridges and valleys in the Snowy Range and carried the rock debris down into the lower valleys.

Geologically, this spectacular range represents a Laramide uplift with an ancient core of Precambrian crystalline rocks, overlain by younger, less deformed, Phanerozoic (see **Appendix A** for definitions of this and other geologic terms) sedimentary rocks. The range is bounded by faults. Along the eastern flank of the Medicine Bow Mountains, the ancient Precambrian rocks were thrust over much younger sedimentary rocks in the adjacent basinal areas.

The ancient Precambrian rocks of the Medicine Bow Mountains have been studied in detail by Houston and others (1968). This, and later works, show the Medicine Bow Mountains to be divided by a major structural feature, known as a suture, that runs roughly east-west to northeasterly through the central part of the Medicine Bow Mountains (**Figure 1**). A suture is a major structural boundary between different geologic provinces. In fact, the Snowy Range Scenic Byway crosses part of this structure near the Nash Fork campground east of the Snowy Range Pass. This suture is expressed as a shear zone that was originally named the Mullen Creek-Nash Fork shear zone. This shear zone is actually part of a much larger regional shear zone known as the Cheyenne belt. The Cheyenne belt has been traced westward

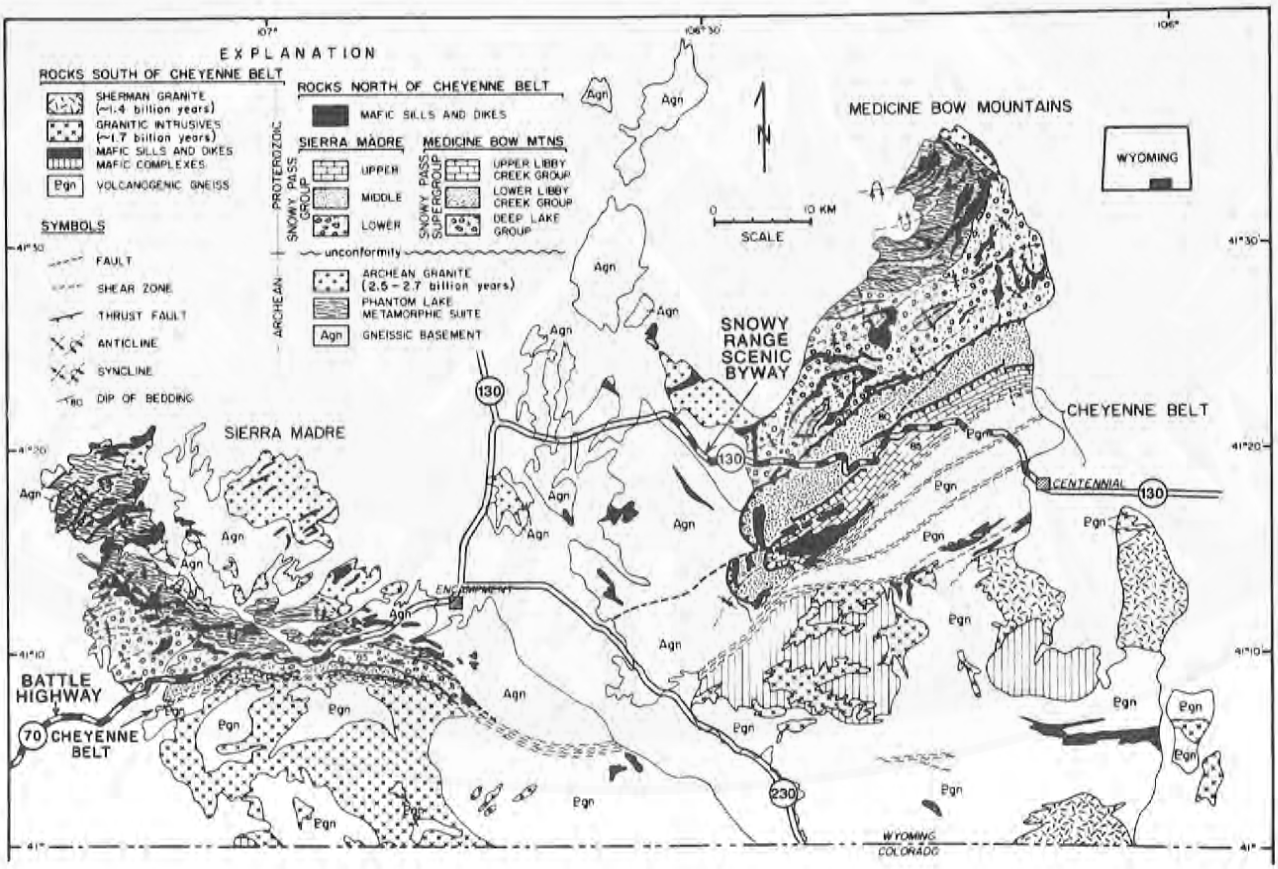


Figure 1. Generalized geologic map of Precambrian rocks of the Medicine Bow Mountains and Sierra Madre, Wyoming. Double line and circled numbers indicate State highways; approximate location of the Snowy Range Scenic Byway and Battle Highway is shown by heavy dashed line (modified and adapted from Karlstrom and others, 1983).

into the Sierra Madre and is projected to the east under the sedimentary rocks of the Laramie Basin and into the Laramie Range.

On the north side of the shear zone, the rocks are significantly different from those to the south. To the north, the Medicine Bow Mountains are underlain by Archean (greater than 2.5 billion years old) crystalline basement rocks that represent part of an early continental core, or "craton". These very old crystalline rocks were buried by a very thick succession of younger (2.5 to about 1.7 billion year old) rocks that are predominantly metamorphosed sedimentary rocks with minor amounts of volcanic rocks.

The rocks south of the Cheyenne belt consist of younger (2.0 to 1.8 billion years old) intensely deformed and metamorphosed sedimentary and volcanic rocks that are now schists and gneisses. These rocks were extensively intruded by granite plutons and mafic complexes 1.8 to 1.4 billion years ago.

The Archean crystalline basement north of the Cheyenne belt (shear zone) is also exposed in several other mountain ranges in Wyoming as well as in northern Utah, northeastern Nevada, eastern Idaho, large portions of Montana, and extreme northwestern South Dakota, and presumably is hidden under much younger Phanerozoic sedimentary rocks in the intervening basins between the mountain ranges. About 2.5 to 2.0 billion years ago, this area represented a small continent with many streams and rivers flowing from the craton into the surrounding oceans.

The younger rocks above the Archean basement north of the Cheyenne belt were deposited in a basin, near the margin of the ancient continent. In total, this succession consists of more than 42,000 feet of quartzite, conglomerate, phyllite, and lesser basalt and dolomite deposited in rivers, braided streams, and shallow seas, or derived from scattered volcanoes.

Rocks south of the Cheyenne belt were originally sedimentary and volcanic rocks deposited in an ocean basin and in volcanic island chains. Before being metamorphosed, the rocks consisted of basalt, andesite, and rhyolite flows, volcanic ash, mafic intrusives, shales, and greywackes.

Rocks north of the Cheyenne belt

A large segment of the Snowy Range highway lies north of the Cheyenne belt (**Figure 1**). The rocks north of the belt are divided into four groups or suites, each of which are further subdivided into formations (**Figure 2**; Houston and others, 1992) that lie on a basement of ancient (Archean) gneiss. These groups are in ascending order: the Phantom Lake Metamorphic Suite, the Deep Lake Group, the Lower Libby Creek Group, and the Upper Libby Creek Group.

The ancient gneissic basement is overlain by Archean (greater than 2.5 billion years old) rocks of the *Phantom Lake Metamorphic Suite*. These rocks consist of as much as 15,000 feet of metaconglomerate, volcaniclastics, and quartzite exposed along the northern flank of the Medicine Bow Mountains. The Phantom Lake Metamorphic Suite is, in turn, overlain by about 8,000 feet of Proterozoic (less than 2.5 billion years old) quartzite and conglomerate, with lesser amounts of mica schist and marble that form the *Deep Lake Group*. The base of the Deep Lake Group includes uranium-bearing, quartz-pebble conglomerate of the Magnolia Formation (Houston and others, 1977, 1979), described by Houston and others (1968) and Karlstrom and others (1981, 1983) as being similar to the uranium ores near Elliot Lake, Ontario. In the Onemile Creek area in the northern Medicine Bow Mountains, Magnolia Formation conglomerates are radioactive and have zones with as much as 0.16 percent uranium.

Conglomerates in the Magnolia Formation contain quartzite pebbles in a pyrite-rich matrix. Radioactive minerals are primarily monazite, coffinite, and various uranium and thorium minerals with the chemical characteristics of a mineral called huttonite (Houston and Graff, 1991) (see **Appendix B**). Generally, the conglomerate is thought to be fluvial (stream deposited) having been later modified through metamorphism (Snyder and others, 1989). The conglomerate grades laterally and upward into quartzite and is thought to have been deposited in a southwesterly flowing river system draining from a highland to the north.

Rocks of the Deep Lake Group are overlain by the *Lower Libby Creek Group* which consists of 14,000 feet of quartzite, paraconglomerate, schist, and phyllite. The formations containing quartzite are

very thick and include the prominent Medicine Peak Quartzite and the Sugarloaf Quartzite which form the ridges, peaks, and prominent outcrops atop the Snowy Range. These quartzites retain a number of sedimentary structures such as cross bedding, channels, and ripple marks created on a river delta.

A major change in depositional environments occurred from deposition of the Lower Libby Creek Group to deposition of the *Upper Libby Creek Group*. The rocks of the Upper Libby Creek Group are more varied and were deposited as sediments in an open marine (ocean) or nearshore environment. The Up-

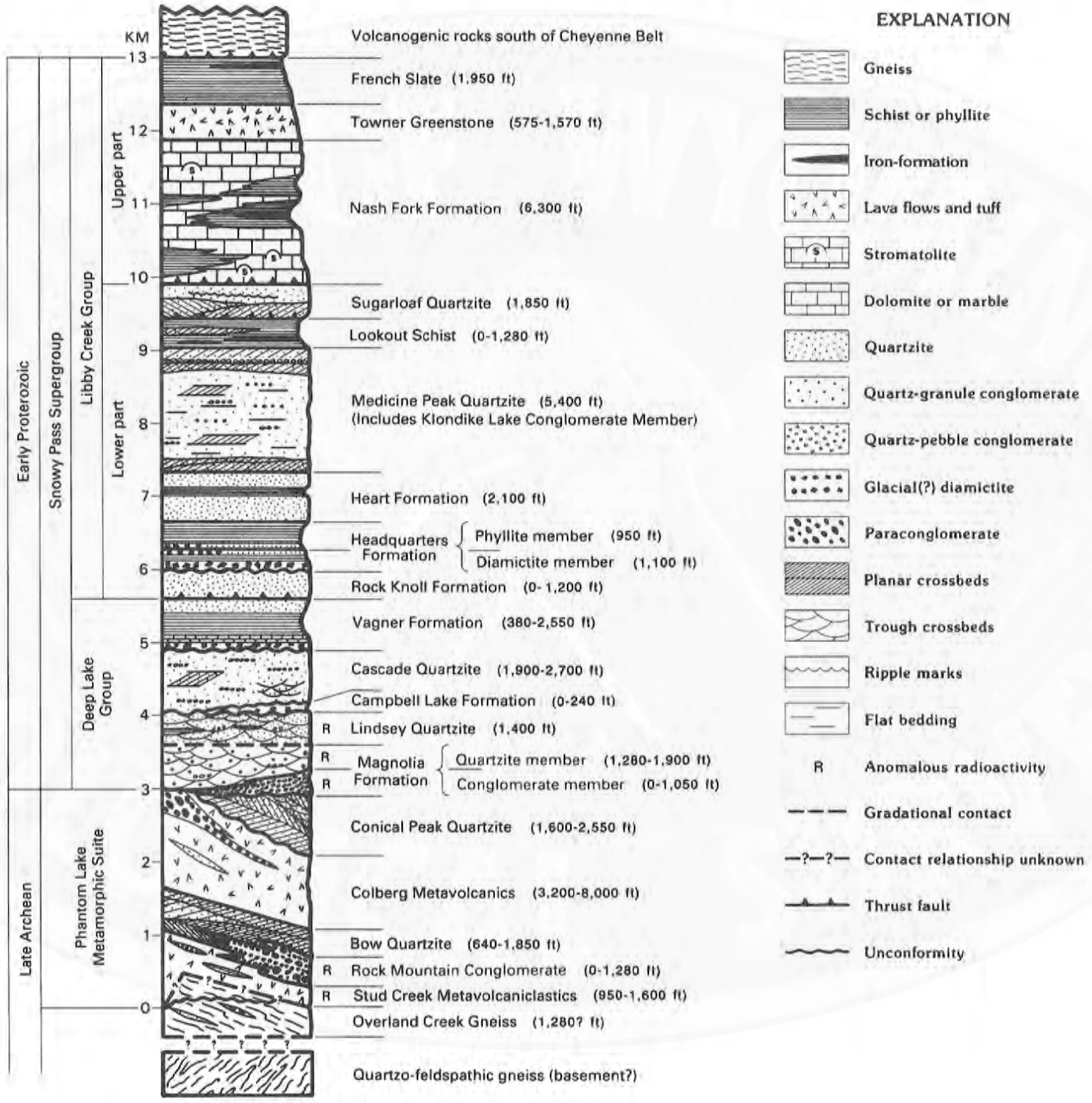


Figure 2. Stratigraphic column of metasedimentary rocks in the Medicine Bow Mountains (modified and adapted from Houston and others, 1992).

per Libby Creek Group includes stromatolitic dolomite, metabasalt, and black feruginous slate and phyllite. Typically, these rock types are formed in shallow water intertidal flats, with the exception of the ferruginous slate that is more characteristic of relatively deep oceanic environments.

Rocks south of the Cheyenne belt

South of the Cheyenne belt, the Medicine Bow Mountains consist of a complex of quartzofeldspathic gneiss and interlayered hornblende gneiss and amphibolite. Intense deformation and recrystallization by metamorphic processes make it difficult to determine their precursors and how they formed. Most likely, they were deposited as mafic intrusive rocks and basalt, andesite, and rhyolite flows and volcanic ash layers (tuffs) from volcanoes, shales, and greywackes (micaceous sandstones). They were later intruded by several igneous masses and plutons including the 34-square-mile Keystone quartz diorite, gabbro dikes, some granite and quartz monzonite plutons, the 60-square-mile Mullen Creek mafic complex, and the 25-square-mile Lake Owen mafic complex (Houston and others, 1968).

Assuming rocks south of the Mullen Creek-Nash Fork shear zone (Cheyenne belt) in the Medicine Bow Mountains are similar to those exposed south of the Cheyenne belt in the nearby Sierra Madre range to the west (**Figure 1**), we can better appreciate and understand the less well-preserved rocks in the southern Medicine Bow Mountains. The rocks south of the Cheyenne belt in the Sierra Madre are a variety of relatively well preserved metamorphosed volcanic and sedimentary rocks which include basalt, andesite, and rhyolite flows as well as tuffaceous rocks, shales and greywackes. Evidence of volcanic vents has also been found. These rocks are typically found in or adjacent to volcanic island arcs.

Areas of interest

The Medicine Bow Mountains encompass a large mountainous uplift of more than 900 square miles of which the Snowy Range is only a small part. The Snowy Range is generally considered to encompass only those high perennial snow-covered quartzite peaks near the summit of the scenic byway. The remainder of the Medicine Bow Mountains also has many interesting areas and many campgrounds. Some of these areas have paved roads and other areas are accessible by graded roads and trails. You may want to contact the U.S. Forest Service for information on roads and conditions. The Forest Service has district offices in Laramie, Encampment, and Saratoga as well as a seasonal information center located one mile west of Centennial (see **Plate 1**). A regional map of this area is available from the Forest Service. Detailed topographic and geologic maps of the Medicine Bow Mountains are available from the Geological Survey of Wyoming. Additionally, the Survey has a small contingent of geologists who are available to help you identify any rocks you might pick up in Wyoming.

During your drive along the Snowy Range Scenic Byway (State Highway 130), you will pass many interesting rock formations and features. I've selected some of the more interesting places that you may want to stop at for a short period of time and take a closer look. Be very careful when stopping or parking alongside the road and be sure to take your camera. I have also selected several localities of historical and/or geological interest outside the Scenic Byway but within the Medicine Bow Mountains and adjacent areas that I think you'll enjoy. All of these localities are shown on the map in the back pocket of this publication (**Plate 1**).

Locality 1
Gateway to the Snowy Range

Anywhere along that part of the Snowy Range highway that crosses the Laramie Basin, from about one mile west of the Herrick Lane (State Highway 12) turnoff to the Overland Trail turnout (**Locality 2**), is a good place to view the gateway to the Snowy Range and the Medicine Bow Mountains. Jelm Mountain, Sheep Mountain, Centennial Ridge, the Snowy Range, and Cooper Hill are all visible on the western horizon on a clear day from this vantage point (**Figure 3**).

In the foreground only a short distance south of the road is Big Hollow. This huge wind excavated depression (basin) covers an area of more than 25 square miles and is about 9 miles long, 3 miles wide, and 150 feet deep. No streams or rivers drain the

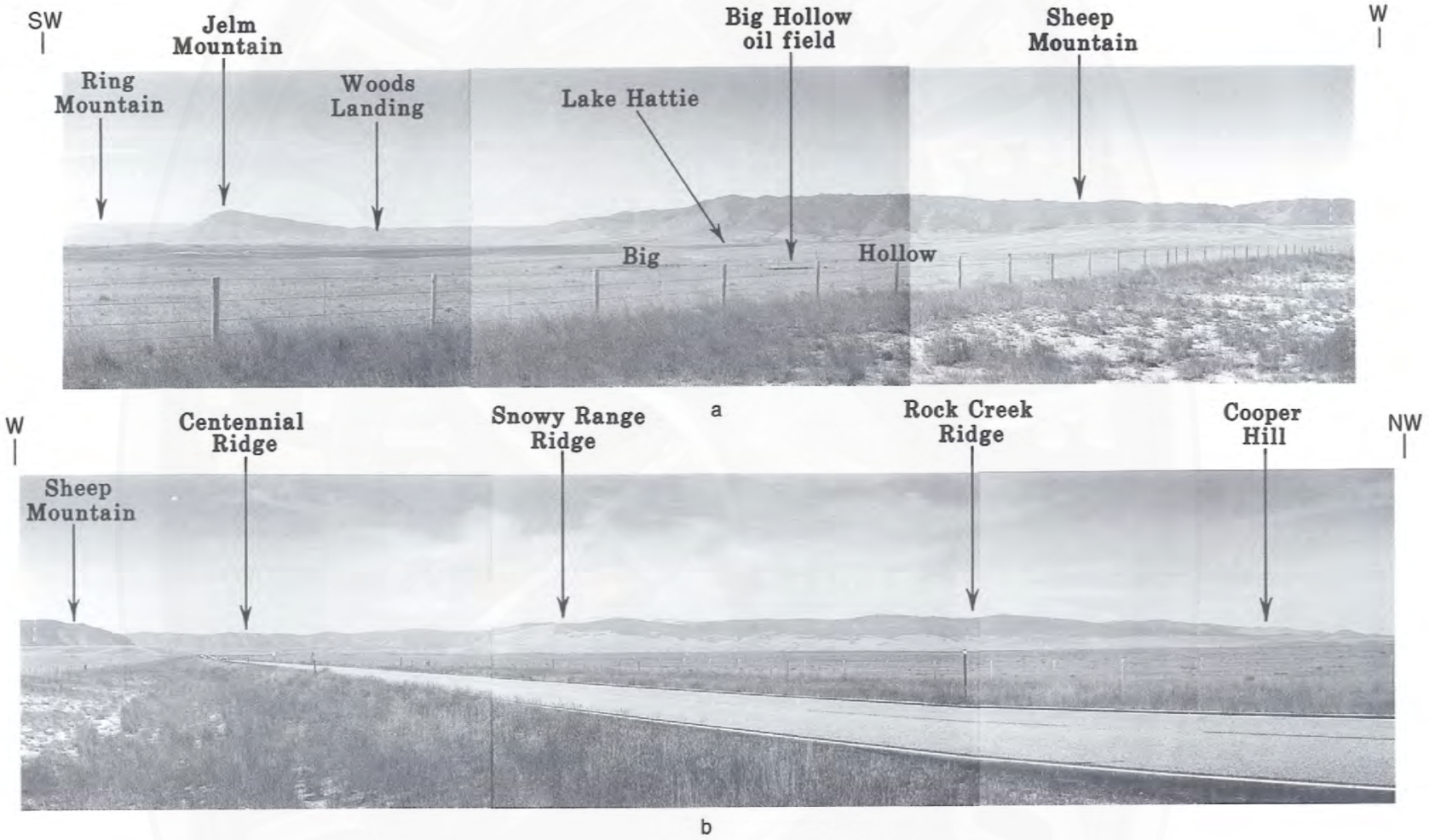


Figure 3. Panorama of the gateway to the Snowy Range and Medicine Bow Mountains viewed from Wyoming Highway 130 east of the Snowy Range. The road sits on the Airport pediment surface. (a) Jelm Mountain to north end of Sheep Mountain. In the foreground a few yards south of the road and fence is the 150-foot-deep Big Hollow. The lone peak on the left (southwest) is Jelm Mountain, capped by the University of Wyoming's infrared telescope observatory. On the horizon north (right) of Jelm Mountain is a long prominent ridge called Sheep Mountain, and lying in the Big Hollow basin east of Sheep Mountain is the Big Hollow oil field. (b) North end of Sheep Mountain to Cooper Hill. Highway 130 points at Centennial Ridge, the prominent ridge in the distance slightly to the north and west of Sheep Mountain. The Snowy Range rises above the rest of the Medicine Bow Mountains as the perennial, snow-covered peaks. Cooper Hill forms a distinct bald (treeless) hill on the right side of this photograph mosaic. (Photographs by Richard W. Jones, 1993.)

basin. The basin probably formed by strong winds that have persisted in the area over a long period of time. Similar, but smaller wind deflation features are found at a number of sites along the western edge of the Laramie Basin. Many of these are now filled with water, such as Lake Hattie and Porter Lake.

Locality 2
Overland Trail historical marker

Look for the turnout on the north side of the highway at this locality (**Figure** 4). The Overland Trail was used extensively between 1862 to 1868, but Larson (1990) points out that the trail was also used as late as 1900, but to a lesser degree. The trail ran through the Laramie plains, skirted the northern Medicine Bow Mountains, turned southwestward into Saratoga, and continued westward to Fort Bridger in southwestern Wyoming.

In 1876, gold was discovered in the loose dirt of the Overland Trail near the present site of Arlington, about 20 miles to the northwest of here. A gold rush to the area led to hydraulic gold placer mining. The mining operations were sporadic but were reported to be active in 1877 and in 1897 (Hausel, 1993). Evidence of one of the historical gold mines is found in Emigrant Gulch immediately north of Interstate 80, one mile west of Arlington. Gravel tailings, washed from stream banks by giants (hydraulic monitors), mark the site of the historical gold operations in Emigrant Gulch. The Overland Trail is visible within a few yards east of the gravel piles.

Fort Halleck (1862-1866) was built near Elk Mountain farther to the west (at the north end of the Medicine Bow Mountains) to provide protection for travelers on the trail. The fort was later abandoned when Fort Fred Steele was established farther to the west along the Platte River. One of the more famous passengers of the Overland stage line which used the trail was Mark Twain, who described some of his experiences in the western classic *Roughing It*.

Locality 3
Big Hollow oil field

The Big Hollow oil field is visible south from Highway 130 at the intersection of State Highway 130 with Albany County Road 44. This field was discovered in 1938 and is currently producing oil from the Muddy Sandstone (Early Cretaceous) at a depth of 800 feet. The oil is structurally controlled and trapped in the Big Hollow anticline (Hausel and Jones, 1984).

Figure 4. Wagon wheel trail ruts are still clearly visible to the right of the historic Overland Trail monument (Photograph by Sheila Roberts, 1991.)

Locality 4
Table Mountain

Table Mountain is the prominent, flattopped hill about one mile south of the highway. This hill is an erosional remnant of the Table Mountain pediment surface (Hausel and Jones, 1984) (**Figure 5**).

As the road proceeds west, down from the high bench into the Little Laramie River valley, a small lake (or pond) is visible south of the highway. This is Porter Lake, a small, often water-filled, wind deflation feature.

Locality 5
Titaniferous black sandstone

Near the base of Sheep Mountain, about a mile south of Highway 130, is a small, 4- to 6-foot-high, low-lying dark outcrop. The outcrop is formed of titaniferous black sandstone of the Mesaverde Formation (Late Cretaceous).

The sandstone is up to 17 feet thick and has been traced for 4,300 feet along the northeastern edge of Sheep Mountain using a magnetometer (Hausel and Jones, 1982). The sandstone represents a fossil beach placer that was formed along the edge of an ancient sea that existed in the area from about 90 to 63 million years ago. Relatively heavy minerals (many which are black and opaque) were concentrated at the prehistoric shoreline by wave action.

The sandstone is rich in magnetite and zircon, and contains ilmenite with minor amounts of rutile, sphene, monazite, garnet, and spinel, as well as anomalous gold (Houston and Murphy, 1962). These titaniferous black sandstones are considered important sources for a number of strategic metals including titanium, iron, zirconium, rare earth elements, and gold. Similar deposits currently form along the coast of Florida, where they are also mined.

Centennial Valley

The highway between Porter Lake and Centennial traverses the north end of Centennial Valley. Structurally, Centennial Valley is a north-south trending syncline. Paleozoic and Mesozoic rocks dip 45°W on the east side of the syncline and 45°E on the west side of the syncline. The east side of Centennial Valley is bounded by Sheep Mountain, an uplift cored by Precambrian Sherman Granite. The east side of Sheep Mountain is thrust up and over steeply dipping to overturned rocks on the west flank of the Laramie Basin. The granite on the east side of Sheep Mountain is in fault contact with rocks as old as Pennsylvanian and as young as Upper Cretaceous; the fault is located at the base of Sheep Mountain near the break in slope where the pine trees begin.

Figure 5. Table Mountain, the distinct flattopped hill south of the highway, is an erosional remnant of the once extensive Table Mountain surface. (Photograph by Sheila Roberts, 1991.)

Centennial Valley syncline is filled with sedimentary rocks as young as the Upper Cretaceous Steele Shale. The southwestern edge of the valley is bounded by a thrust fault. The west side of the valley is a normal (unfaulted) sequence of eastward-dipping Paleozoic and Mesozoic rocks. On the north side of Centennial Valley between Corner Mountain and Bald Mountain, Precambrian gneissic rocks are thrust eastward over rocks as young as the Tertiary Hanna Formation. The Hanna Formation occupies the shallow, but sharply folded, Mill Creek syncline just east of Bald Mountain. The axis of the Mill Creek syncline joins the synclinal axis of Centennial Valley.

Several miles north of the junction of State Highway 130 with State Highway 11 to Albany, the Upper Cretaceous Mesaverde Formation is exposed at the crest of Rex Lake anticline, an oil-producing structure. For more details on the geology and structure of the eastern part of the Medicine Bow Mountains, the reader is referred to Blackstone (1970, 1973, and 1975), Houston and others (1968), and Hausel and Jones (1984).

Locality 6
Centennial Valley boulder field

As you enter Centennial Valley from the east or the west, extensive boulder fields are visible on both sides of the highway. In the relatively recent geologic past, during the Pleistocene Epoch (1.6 million to 10,000 years ago), the high peaks of the Snowy Range were periodically covered by alpine glaciers. These glaciers carved paths into the range and carried large loads of boulders and other eroded debris. This debris was carried down into the lower valleys by both ice and melt waters. The finer material was removed by running water, leaving an extensive outwash plain that now covers the floor of Centennial Valley (**Figure 6**). Many of the boulders are composed of white quartzite, which originated from the Medicine Bow Peak area about 10 to 12 miles to the west.

Figure 6. Glacial outwash plain (boulder field) from the last Ice Age. This area of Centennial Valley is covered by an extensive field of boulders that originated in the high peaks of the Snowy Range. (Photograph by Sheila Roberts, 1991.)

Locality 7
Centennial

The town of Centennial was a gateway to mining and logging activities in the Medicine Bow Mountains in the late 1800s (**Figure 7**). Founded in 1876, the town was named in honor of the Nation's Centennial anniversary. Today, Centennial is the home for about 100 residents. Many cabins, homes, a museum, and a few restaurants form much of the town.

Locality 8
Centennial Ridge district

Centennial Ridge is the prominent ridge that abruptly rises from the basin floor immediately west of Centennial. Gold was discovered along Centennial Ridge in 1874, and was also found in the Middle Fork of the Little Laramie River even earlier (**Figure 8**). A short time later in 1876, the Centennial Ridge mining district was organized.

Mining began in 1875 at the Centennial mine as well as at some other mines in the district. But after a few years, the rich gold vein at the Centennial mine was lost at a fault offset. The extension of the vein beyond the fault was never found, and interest in the district declined. In the early 1900s, some renewed interest in mining followed the discovery of platinum, but the reports on the amount of platinum in the lodes were exaggerated.

Both lode (vein-related) and placer (stream transported) gold and platinum have been found in the Centennial Ridge district (McCallum, 1968; Hausel, 1989). The lode gold generally occurs in quartz veins hosted by mica and hornblende schist and gneiss, and the lode gold-platinum occurs as

Figure 7. View of Centennial with Centennial Ridge in the background, showing the location of a prospect pit (arrow) above the main tunnel of the Centennial mine. The main adit is hidden in the trees below. (Photograph by Richard W. Jones, 1993.)

Locality 9
Centennial mine

The adit (horizontal tunnel entrance) of the Centennial mine is hidden in the trees west of the town of Centennial, but a small prospect pit can be seen above the adit (**Figure 7**).

The Centennial claim was staked in 1875, and within a short time, gold was mined from the Centennial lode. At this time, the Centennial mine was the center of attraction in the Medicine Bow Mountains. As the ore was mined, it was hauled out of the tunnel in ore cars, dumped into buckets suspended from a tramway at the mine adit, and lowered 260 feet down into the valley along a 425-foot-long tramway (Duncan, 1990). At the base of the tramway, the ore was received in a 10-stamp mill where it was crushed and processed (**Figure 9**). Much of the gold was recovered on amalgamation plates where the gold combined with mercury. The mercury-gold amalgam was later retorted (heated in an enclosed cylinder) to separate the gold from the mercury. However, much of the refractory gold occurring in pyrite could not be recovered by this method and was lost in the tailings.

fracture fillings and replacements in faults and shear zones in the schist and gneiss (McCallum, 1968). Gold and platinum are commonly associated with pyrite (a brittle, metallic, bronze-colored, iron sulfide, referred to as fool's gold by prospectors), and arsenopyrite (a metallic, silver-colored, arsenic-iron sulfide). Placer gold and platinum generally occur as small flakes about the size of a pinhead or pinpoint (known as "colors") along Fall Creek and the Middle Fork. Nuggets are uncommon.

Figure 8. Remains of the early gold rush in the Centennial Ridge mining district. The Queen mine headframe on top of Centennial Ridge, as it appeared in 1980, is a reminder of a bygone era.

In the summer of 1877, the Centennial drift was driven from the rich vein into a gouge zone in barren, gray, hornblende gneiss. The vein was offset by a fault! The extension of the lode could not be found and operations terminated. To this day, no one has attempted to locate the extension of the lode with modern exploration techniques.

Available reports indicate the Centennial ore was relatively rich. The vein was said to average 1.5 ounces of gold per ton (Hausel, 1989). Some specimen grade ore shipped to the Denver Mint in 1876 was reported to assay 2,263.02 ounces of gold and 209.98 ounces of silver per ton (Duncan, 1990). Based on 1992 precious metal prices, the value of the metals contained in a ton of this specimen grade rock would be worth

Figure 9. Remains of 3 stamps from the mill at the Utopia mine south of the Centennial mine. These rods are attached to a heavy metal shoe that was mechanically lifted and dropped to crush the gold-bearing rock (ore). The shoe of most stamps generally weighed 1,000 to 2,000 pounds, The Centennial mill included a battery of 10 stamps similar to these.

$750,000 to $900,000. Another sample of specimen grade ore was sent to the 1878 Paris Mining Exposition where it won first prize as a specimen of ore. Another sample of the gold-bearing schist is reportedly part of the Smithsonian collection. Gold production from the mine over its short lifetime was reported at 4,500 ounces (McCallum, 1968).

Locality 10
Platinum City

In about 1930, minor to trace amounts of platinum were found in some ores in the Centennial Ridge district. Several gold mines reopened including the Platinum City mine (**Figure 10**) south of the Centennial and Utopia gold mines. However, the rebirth of the district was only short-lived.

The platinum values in the ores were apparently greatly exaggerated by a local promoter who began to lay out plans for a town called Platinum City, about 2 miles south of Centennial along the Union Pacific Railroad right-of-way. The mine above the town was named the Platinum City mine. But the mine and the townsite were doomed from the beginning, and the promoter was indicted in mail fraud related to the exaggerated stories of unusually rich platinum ore (Thybony and others, 1985).

Figure 10. The historic Platinum City mine dump as it looked in 1980 from Centennial Ridge.

Locality 11
Snowy Range lodge (Libby lodge)

If you drive along the Barber Lake Road (Forest Service Road 351), you will pass an old log lodge on the south side of the road (**Figure 11**). Construction on this lodge began in 1924 and included 17 rooms on the second and third floors. The main floor was used for dining and offices, and included a dance hall and kitchen (Thybony and others, 1985). Today, the lodge serves as a private residence with the main floor available for various celebrations and events. The current residents have taken great care to restore and preserve this historical structure.

Located about 1.5 miles above the lodge was the Libby Creek ski area constructed by the Brush Creek CCC camp prior to the second World War. The resort reopened after the war but closed permanently in 1953. According to Thybony and others (1985) the resort had a chair lift and two rope tows. The main ski run had an incredibly steep slope with 25 to 60 percent grades!

Locality 12
Cataclastic biotite augen gneiss and schist

Outcrops of gneiss and schist are visible in road cuts along the Barber Lake Road (Forest Service Road 351), and at Corner Mountain on the Snowy Range Scenic Byway (State Highway 130) (**Figure 12** and **Plate 2**).

These rocks are intensely deformed and metamorphosed such that it is difficult to determine how they originally formed. However, based on the rock mineralogy, geochemistry, and geological setting, most likely these were originally greywackes (micaceous sandstones) (Snyder and others, 1989). The intense deformation and metamorphism that these rocks were subjected to resulted in the melting of portions of the rock, producing aluminous granites, dikes, and veins. The veins are often folded and typically have been stretched in the vertical plane producing boudins (link sausage-like morphologies).

Figure 11. Snowy Range lodge on the Barber Lake road.

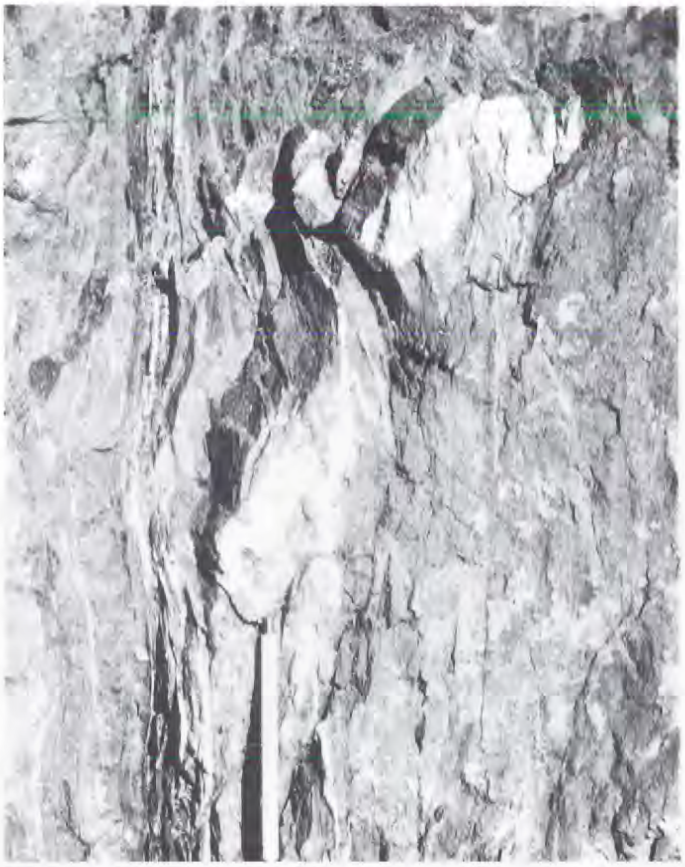


Figure 12. Folded veins in cataclastic augen gneiss in a road cut along the Barber Lake road.

Locality 13
Medicine Bow ski resort

The Medicine Bow ski resort south of the highway (**Figure 13**) is open to the public during the winter months. This is the only active ski resort in southeastern Wyoming. The resort opened in 1960 (Thybony and others, 1985).

Locality 14
Mullen Creek-Nash Fork shear zone

Fifty to 100 yards south of the highway is an exposure of sheared gneiss cropping out in the south bank of Telephone Creek west of the Wilderness camp (formerly the University of Wyoming's S.H. Knight science camp). The gneiss (**Figure 14**) is part of the Mullen Creek-Nash Fork shear zone which is poorly exposed in this area. The shear zone is part of the Cheyenne belt that separates younger rocks to the south from older rocks to the north.

The gneiss is deformed with abundant parallel fractures and microfractures producing mylonite which is cut by some coherent pink, folded, felsic layers. Movement along the shear zone (fault) occurred between 1.73 and 1.64 billion years ago (Hills and Houston, 1979).

Locality 15
Nash Fork campground

Turn off the highway and drive to the western edge of the campground and park near the campground bulletin board. Walk 20 to 30 yards west to a dark brown to black rock outcrop along the edge of the highway. This is finely laminated graphitic slate and phyllite of the French Slate (Upper Libby Creek Group) (**Plate 2**). The slate has been deformed by movement along the adjacent Mullen Creek-Nash Fork shear zone and has produced some spectacular, complexly folded and crenulated beds (**Figures 15** and **16**). These rocks have been folded at least two different times (**Figure 15**).

There is evidence of glaciation at this stop. The outcrop of the folded, dark, French Slate has some large, white, quartzite boulders (glacial erratics) sitting on it (**Figure 17**). During the Ice Age, these boulders were carried by a glacier from the Snowy Range ridge area and deposited here when the ice melted.

Locality 16
St. Albuns Chapel

As you leave the Nash Fork campground, turn left (north) on Forest Service Road 317 towards Brooklyn Lake. Within a mile, you will come across St. Albuns Episcopal Chapel on the right (east) side of the road. This is an open air chapel east of Little Brooklyn Lake constructed of logs and slabs of rocks found in the nearby area. The floor and altar are made from

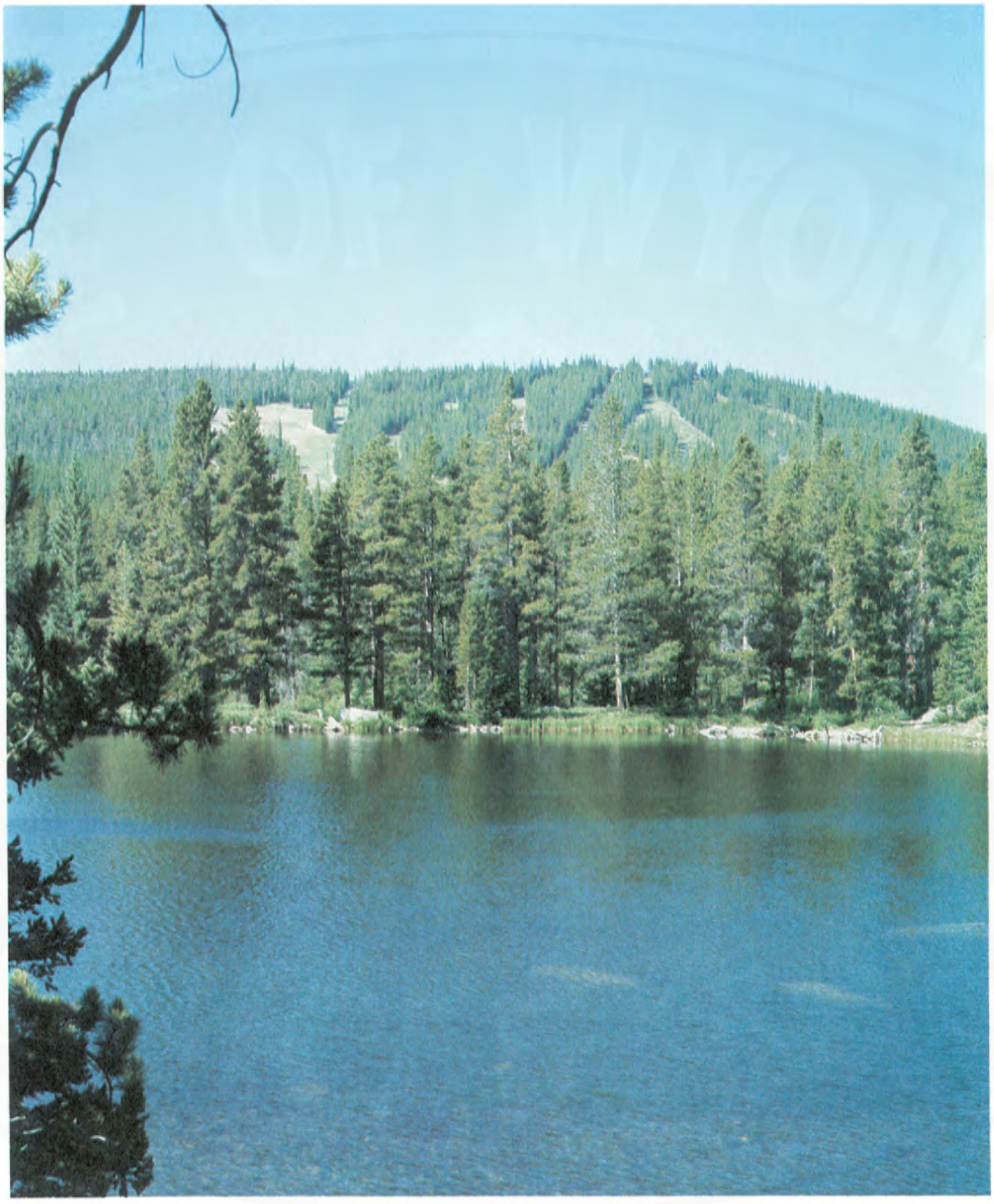


Figure 13. View of the Medicine Bow ski resort from Hanging Lake.

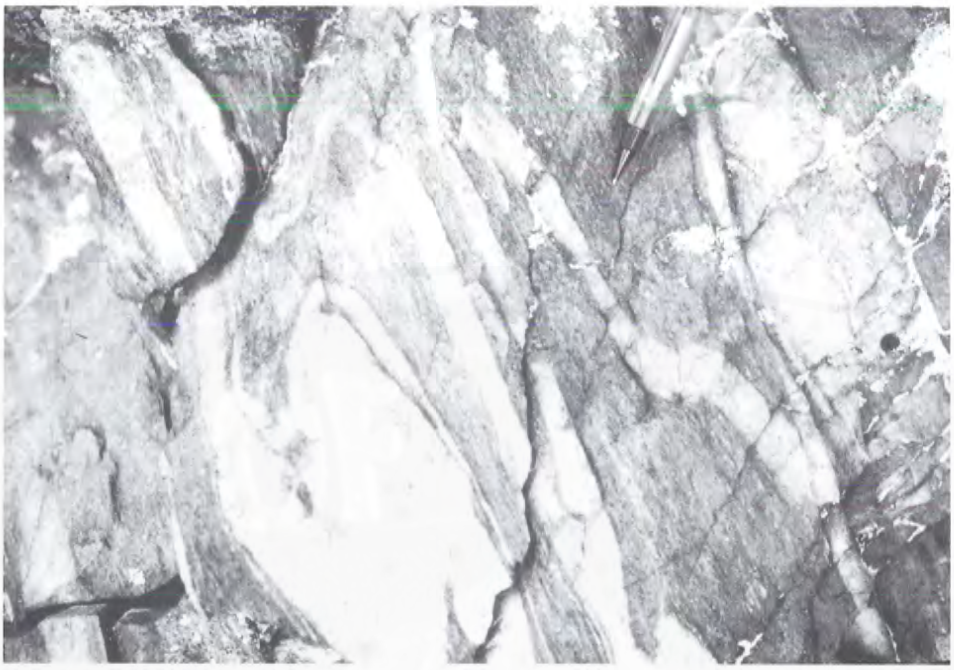


Figure 14. Sheared gneiss of the Mullen Creek-Nash Fork shear zone (Cheyenne belt). The gray material contains many closely spaced parallel fractures, which produce an intensely fractured rock known as mylonite. The light material was folded during differential movement along the fractures.

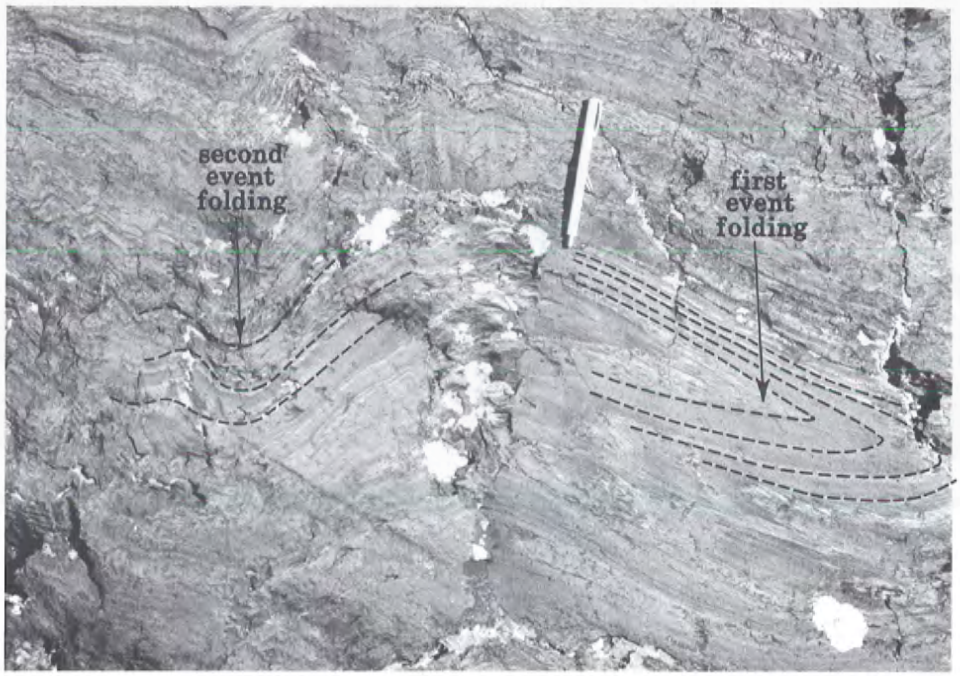


Figure 15. Folded French Slate at the Nash Fork campground. An early folding event produced tight (isoclinal) folds with parallel limbs. These were later refolded by open buckle folds.

Figure 16. The same outcrop of French Slate at Nash Fork campground as shown in **Figure 15** contains many spectacular crenulated beds (chevron folds) produced during the refolding of these rocks.

common slabs of slate and greenstone, and the small, round, rock podium is made of slabs of colored quartzites and quartz (**Figure 18**).

Locality 17
Sugarloaf recreation area

A small Forest Service sign on the north side of the Snowy Range Byway marks the turnoff to the Sugarloaf recreation area. Turn here and drive north along the graded road. The road will cross two small creeks within a quarter of a mile of the turnoff. After crossing the second creek continue about 0.1 to 0.2 mile. On the right side (east) of the road is a grayish-tan to tan outcrop. This is metadolomite of the Nash Fork Formation (Upper Libby Creek Group) which contains fossil evidence of some of the oldest lifeforms on earth, known as stromatolites (**Figure 19**).

Figure 17. Large white glacial erratic quartzite boulders sit on the dark French Slate adjacent to the Nash Fork campground. These boulders were picked up by a glacier in the Medicine Bow Peak area 3 to 4 miles to the west.

Stomatolites are layers of carbonate material (originally arranged in horizontal mats, domes, columns, or semispheres) deposited in shallow marine water by the influence of blue-green algae. Colonies of the algae trapped fine silty detritus and precipitated calcium carbonate bioherms (domes) and reefs. These stromatolites were deposited almost two billion years ago and have since been fossilized, deeply buried and metamorphosed, tilted to vertical, and later exposed by erosion

Knight and Keefer (1966) and Knight (1968)

Figure 18. St. Albuns Chapel near Brooklyn Lake is constructed from a variety of quartzites, slates, quartz, and greenstones found in the nearby area.

mapped about 150 bioherms (domes) and 3 reefs in this area. The reefs are about 200 feet thick and 2,000 to 3,000 feet long. The individual bioherms are typically less than one foot across. Incidentally, the shapes of the bioherms can be used to tell which way was up at the time of deposition. This is important, since the rocks in the Medicine Bow Mountains have been compressed, crushed, tilted, and fragmented several times during the past two billion years. Without features like stromatolites, it would be difficult to determine which rock units are upright, which ones are overturned, and which ones are entirely out of place.

Figure 19. Stromatolite domes (with pen for scale) of the Nash Fork Formation (Upper Libby Creek Group) deposited in an ancient ocean more than 1.7 billion years ago. View is to the west. Using the shapes of the bioherms, it is possible to determine which way was up when these rocks were initially deposited. The v-shaped limbs of the bioherm point to the ground at the time of deposition, thus the top of the unit was to the south (left). Therefore, these rocks have been tilted through geologic time. (Photograph by Sheila Roberts, 1991.)

Locality 18
Lewis Lake and the Billie Class stamp mill

From the stromatolite outcrop, drive north around the hill and Libby Lake will appear on the left (west) side of the road. Continue north around the eastern shore of the lake to the Lewis Lake parking lot. From the parking lot, follow the hiking trail around the edge of Lewis Lake to the north shore. Here lie the remains of the Billie Class three-stamp gold mill used sometime between 1890 and 1920 to recover gold from sheared, pyritized hematite-chlorite schist in the Lookout Schist (Lower Libby Creek Group) (**Figure 20**).

As you walk around the old mill site, you will see several prospect pits and trenches. Even today, some greenish, copper-stained rock can be found 100 to 200 yards east of the mill, and bronze-colored pyrite ("fool's gold") occurs in pyritizied schist 50 to 100 yards west of the mill. An iron-stained gossan (rusty rock) altered zone is traceable for 2,000 feet along an easterly trend.

Figure 20. Remains of the Billie Class stamp mill used to extract gold from the nearby rocks. When this prospect was mined, gold prices were only $20.67 for an ounce of gold. In 1990, gold prices averaged 20 times higher! (Photograph by Sheila Roberts, 1991.)

A sample of the pyritized schist collected west of the mill by the U.S. Forest Service in 1990 assayed 0.12 ounce per ton gold (Dersch, 1990). Three samples collected at the same time by the author also confirm the presence of gold. These assayed 0.002, 0.10, and 0.12 ounce per ton gold. For comparison, in 1991 many of the modern gold mines in Nevada and Utah were mining ore averaging about 0.1 ounce per ton gold.

Along the southwestern shore of Lewis Lake, a radioactive quartz vein yielded a sample of rock that contained 0.1 percent uranium, 0.16 percent thorium, and 0.004 ounce per ton gold (Houston and others, 1983).

Locality 19
Northwest shore of Lewis Lake

West and a little south of the Billie Class stamp mill is an interesting outcrop of paraconglomerate on the side of the hill on the northwestern shore of Lewis Lake (**Figure 21**).

The outcrop is formed of rounded to angular pebbles and cobbles of quartzite, schist, and gneiss in a dark gray to blue-gray matrix. Blackwelder (1926) suggested these conglomerates represent tillites deposited along the edge of a glacier during an ice age more than 1.7 billion years ago. Alternatively, the paraconglomerate could represent an ancient landslide (Houston and others, 1968, p. 25).

Locality 20
Libby Flats observation point

The observation platform and adjacent parking lot on the south side of the road are located on metadolomite of the Nash Fork Formation (Upper Libby Creek Group). Libby Flats is the open grassy terrane south and southeast of the observation deck. The area surrounding the observation platform was

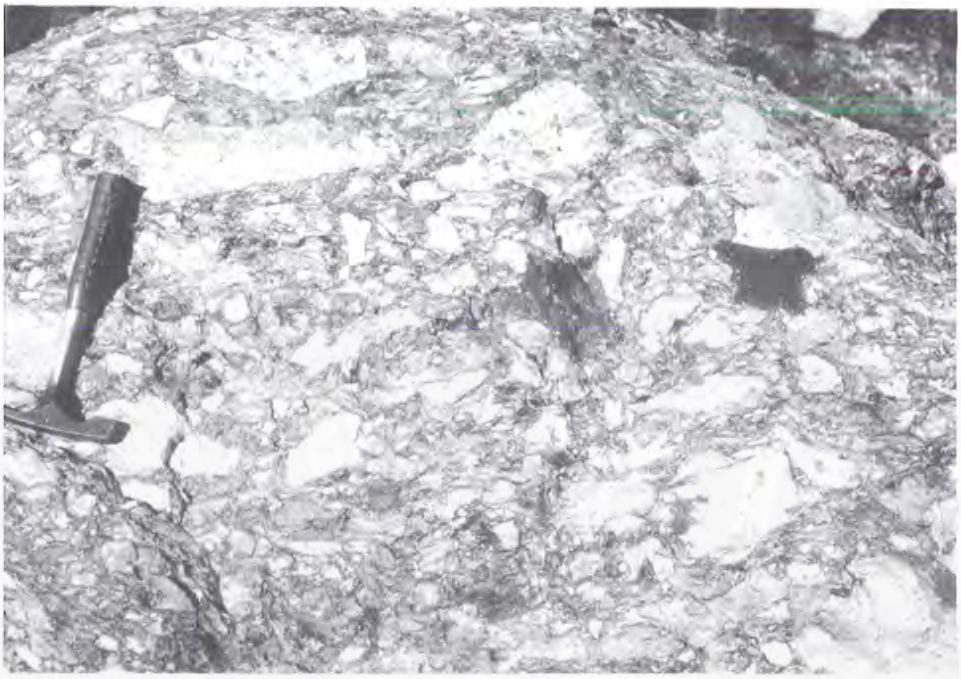


Figure 21. Paraconglomerate. This outcrop is interpreted to represent tillite (material deposited by a glacier) more than 1.7 billion years old! Alternatively, the outcrop could represent a 1.7 billion-year-old landslide deposit.

once known as the LaPlata mining district, which included a number of small prospects and mines as well as the Lewis Lake gold deposit (**Locality 18**), the Red Mask mine (**Locality 22**), the Bellamy Lake copper prospect (**Locality 23**), and the prospect lying about a quarter of a mile to the south (**Locality 21**). The mines and prospects in this district were never developed to any great extent because most of the rocks were poorly mineralized. Although Duncan (1990) discussed rich silver lodes in this district, the author was unable to find significant silver values in the samples to verify the historical reports.

To the southwest in the far distance, one can see the Saratoga Valley with the Sierra Madre range on the horizon. The Sierra Madre is geologically similar to the Medicine Bow Mountains (**Figure 1**), and includes the Encampment (also known as the Grand Encampment) mining district where more than 21 million pounds of copper, 29,000 ounces of silver, and 2,000 ounces of gold were recovered between 1898 and 1911 (Hausel, 1986; 1989).

Locality 21
Libby Flats prospect

About a quarter of a mile south of the Libby Flats observation point, along a jeep trail, are the remains of an historical cabin which marks the site of an old prospect. The prospect is in brecciated metadolomite of the Nash Fork Formation and consists of angular metadolomite clasts cemented by massive and boxwork limonite (**Figure 22**). The limonite boxworks are butterscotch- to tawny-colored, spongy and porous, iron oxides that represent the remains of iron carbonate (siderite). In other words, much of the former iron carbonate has been leached from the rock leaving open pore spaces (vugs) in place of the former crystals. The matrix surrounding the vugs has been replaced by limonite. A sample of the boxworks collected from the prospect contained no detectable gold or silver.

a

b

Figure 22. (a) Metadolomite breccia from the Libby Flats prospect contains large white angular fragments of broken dolomite fragments of the Nash Fork Formation cemented by limonite (light gray). (b) Common vuggy limonite boxworks.

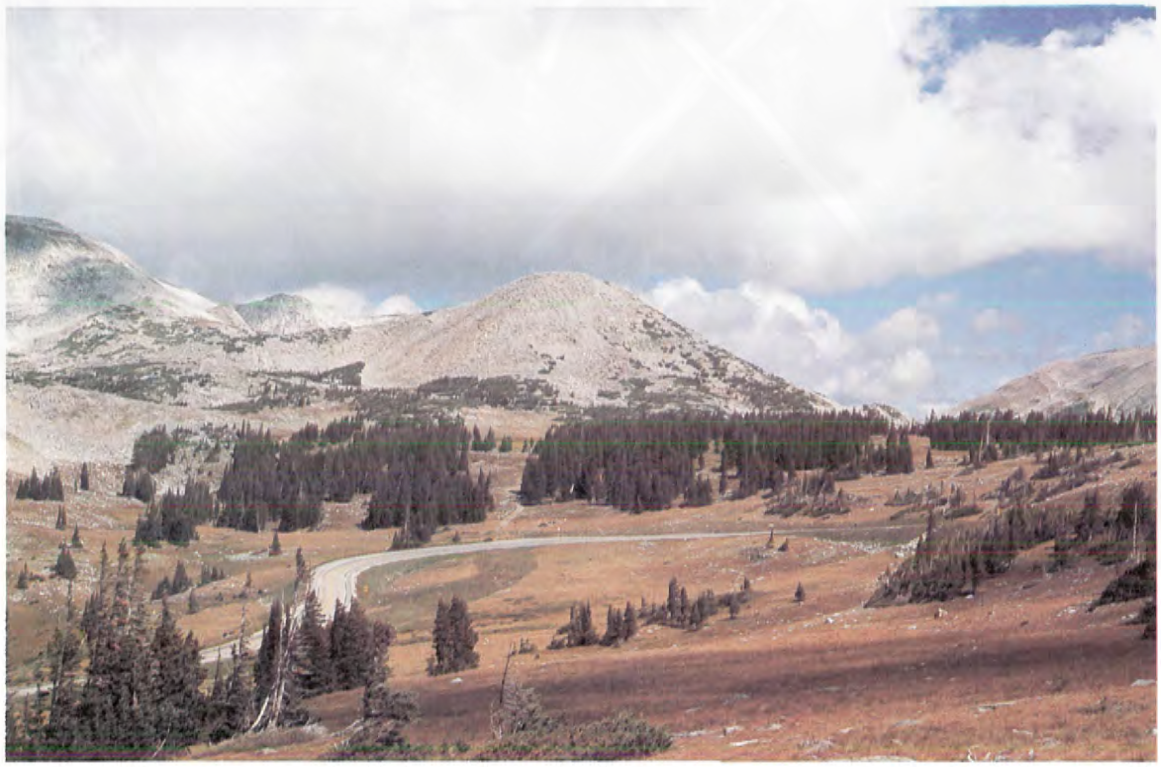
Locality 22 Medicine Bow Peak observation point turnout

On the west side of the road is a turnout with a parking lot. From here, to the northwest one can view Snowy Range ridge (**Figure 23a**) which abruptly rises 1,000 feet above the lakes to a height of 12,013 feet above sea level at Medicine Bow Peak. During past ice ages, the 1,000-foot-high cliff seen from this viewpoint was carved by glaciers in the resistant Medicine Peak Quartzite (Lower Libby Creek Group) (Knight, 1990).

Turn a little bit to your right and look directly north. About a mile distant is a symmetrical, white hill that almost looks like a mound of sugar (**Figure 23b**). This is Sugarloaf Mountain formed of Sugarloaf Quartzite (Lower Libby Creek Group). This mountain is located west of Libby and Lewis Lakes (**Locality 18**). The highest point on Snowy Range ridge just to the left of Sugarloaf Mountain is Medicine Bow Peak.

A short distance south of the parking lot

a



b

Figure 23. (a) View of the Snowy Range ridge cut in Medicine Peak Quartzite (photograph by Sheila Roberts, 1991). (b) Sugarloaf Mountain formed of a mound of white Sugarloaf Quartzite.

(about 30 yards), in the small valley, is the historical Red Mask mine (**Figure 24**). This mine was developed in 1924 (Duncan, 1990, p. 48) but apparently did not produce much gold or silver. A selected sample from the shear zone at the Red Mask mine contained no detectable gold and only a trace of silver (0.02 ounce per ton). The shaft is presently caved and the old wooden headframe, which was used to haul ore and miners from the mine tunnels to the surface, has tipped over. Nearby, there is an old iron steam boiler which was used to supply energy to operate the mine hoist. The mine shaft was sunk on quartz stringers in green chlorite schist, white quartzite, and tan metadolomite.

Locality 23
Bellamy Lake copper prospect

Like the other lakes in this area, Bellamy Lake occupies a small, shallow, glacially-carved basin. Fifty to 100 yards northwest of the lake shoreline is an old copper prospect located on a contact between fractured Sugarloaf Quartzite and a dike of mafic (dark) igneous rock. Minor amounts of quartz with some chalcopyrite (a bronze, metallic, copper pyrite) can be found in chlorite schist. The chlorite schist is part of the mafic dike. A sample of the schist contained no detectable gold, 0.02 ounce per ton silver, and only 0.04 percent copper.

Locality 24
Mirror Lake

Mirror Lake fills a glacially-carved basin in the Sugarloaf Quartzite (**Figure 25**). Outcrops of this quartzite form the low-lying ridges on the north side of the lake. Spectacular outcrops of the Medicine Peak Quartzite form the prominent white cliffs in the background.

Locality 25
Lake Marie

Like Mirror Lake, Lake Marie also occupies a shallow, glacially-carved basin. The south half of the lake is on resistant Sugarloaf Quartzite, while the northern half of the lake lies in laminated, less resistant Lookout Schist.

Figure 24. Remains of the Red Mask mine near the Medicine Bow Peak observation point with Sugarloaf Mountain in the background.

a

b

Figure 25. (a) Mirror Lake fills a shallow glacially-carved basin in quartzite. The small tree-covered hill on the far side of the lake is underlain by Sugarloaf Quartzite and the high cliffs of the Snowy Range ridge at the skyline are underlain by Medicine Peak Quartzite. (b) On the ridge, a dark-colored, mafic igneous dike cuts through the white Medicine Peak Quartzite.

Lake Marie has two parking lots connected by a paved walking path. The Lookout Schist crops out near the stone building adjacent to the western parking lot. A few yards east of this building, the schist is folded and exhibits prominent axial plane cleavage (**Figure 26a**).

Adjacent to the parking lot along the eastern shore of the lake is a field of boulders with rocks derived from both Medicine Peak Quartzite and Sugarloaf Quartzite. The Medicine Peak Quartzite is a highly resistant, medium-to coarse-grained white quartzite with layers of quartz-pebble conglomerate (**Figure 26b**). The quartzite contains minor grains of sericite (white to silver-colored mica), black tourmaline, and light-blue transparent kyanite. The Sugarloaf Quartzite is also a white, medium-grained quartzite with minor sericite and black tourmaline.

Some sedimentary structures preserved in the quartzite boulders provide geologists with clues on the depositional environments. Some of the boulders have bedding, cross bedding, and occasional beds of quartz pebble conglomerate. These suggest the Medicine Peak Quartzite was deposited as quartz sand in a river bed or in the subtidal portions of a delta or an estuary. Paleocurrent directions from quartzite outcrops elsewhere indicate the sediment that formed the quartzite was carried by water in a west-southwest direction. This implies there was a highland source area to the northeast which supplied the sediment. Small scale oscillation ripples in the quartzite suggest some of the quartzite was deposited as quartz sand in shallow water along the edge of an ancient ocean.

Locality 26
Snowy Range ridge and Medicine Bow Peak

Medicine Bow Peak on Snowy Range ridge is the highest point in the Medicine Bow Mountains (12,013 feet) (see **Locality 22**). A trail to the top of the peak is usually accessible by late summer through early fall.

Locality 27
Road to the Gold Hill mining district

A turnoff to the Gold Hill mining district is about 1 1/2 miles north of the Silver Lake campground. Forest Service Road 293 to the Gold Hill district is not designed for automobiles and should not be attempted without a 4-wheel-drive vehicle with good clearance. The historical district is about 2 to 2.5 miles north of the Snowy Range Byway.

Locality 28
Gold Hill mining district

The Gold Hill mining district was organized in 1890 following the discovery of rich gold-quartz veins in the previous year. The veins were generally poorly mineralized with sporadic, small and discontinuous, ore shoots (rich pockets of gold). However, some rare specimen grade material taken from an ore shoot in the Acme mine reportedly assayed as high as 2,100 ounces of gold per ton. (Based on the 1992 prices for gold, the contained metal in a ton of this specimen-grade rock would be worth $735,000 to $850,000.) Gold placers in the district were few and restricted in size.

Unfortunately, the gold was not consistently distributed throughout the veins. This, coupled with the narrow vein widths, resulted in the closure of the mines within a few years. Total production from the district is unknown, but was estimated to have amounted to only about 145 ounces by 1893. Actual production was probably a few times this figure.

The district lies on a north-northeast plunging anticline in Proterozoic metasedimentary and metavolcanic rocks (Karlstrom and Houston, 1979). The core of the anticline is formed of rocks of the Phantom Lake Metamorphic Suite, which includes quartz-pebble conglomerate, quartzite, phyllite, and metavolcanic rocks. This core is overlain by rocks of the Deep Lake Group which includes the Magnolia

a

b

Figure 26. (a) Folding in the schist on the southwestern shore of Lake Marie provides evidence of intense deformation in the Medicine Bow Mountains during the earth's geologic history. (b) Quartz-pebble conglomerate bed (the dark band on the left) in a quartzite boulder on the eastern shore of Lake Marie. The conglomerate bed in this boulder is about four inches thick. (Photograph by Sheila Roberts, 1991.)

Formation (conglomerate and quartzite) and the Lindsey Quartzite.

Today, little remains of the historical mining operations other than the old mine workings, a few decaying log cabins, and rusting steam boilers (**Figure 27a**). Occasionally, some attractive gold specimens are still found on the historical mine dumps (**Figure 27b**).

a

b

Figure 27. (a) Very little remains of the historic Gold Hill mining camp except for a few scattered mining relicts. (b) Gold overlooked by the early miners and recovered by local prospector Dean Farris.

Locality 29
Gold Hill ghost towns

According to Duncan (1990), a few townsites were organized during the gold boom at Gold Hill. The Gold Hill townsite was located in the southern part of the district and was bordered by the Gold City townsite to the northwest.

Two other townsites (Golden Courier and Greenville) were also built. Of these two, Greenville in 1891 included 10 log cabins, 20 tents, two hotels, and a saloon. One of the hotels, the Acme Hotel, was a two-story structure with 14 rooms. In total, the Gold Hill townsites included three hotels, three saloons, a blacksmith shop, a post office, several log cabins, and tents (Duncan, 1990). Today, a few scattered decaying cabins are all that remain of the historical town sites.

Locality 30
Vagner Formation paraconglomerate

Some good exposures of the Vagner Formation paraconglomerate occur immediately west of Dipper Lake on a 4-wheel-drive road (Forest Service Road 103) that forks from the Gold Hill road and continues to the north. The paraconglomerate crops out on the south flank of a small hill a few yards above a couple of prospect pits. The paraconglomerate is dark gray with numerous white granitic pebbles and cobbles (**Figure 28**).

Locality 31
Ryan Park (Barrett Ridge) ski area

No longer in use, the old ski runs south of the road are difficult to see, and have been partially reclaimed by a new growth of pine trees. The ski resort was opened in the winter of 1941-1942 with the aid of the

Figure 28. Vagner Formation paraconglomerate near Dipper Lake. The granitic cobbles are rounded to angular, which suggests that they could not have been transported very far from their source area.

Saratoga CCC camp. The resort was serviced by a 40-chair chairlift. Operations ended in the 1960s (Thybony and others, 1985).

Locality 32
Brush Creek-Mullison Park gold placers

The Brush Creek-Mullison Park area had a very interesting early gold prospecting history (Thybony and others, 1985, p. 93-94). This area was prospected in the late 1800s following the discovery of gold flakes and some small thumb-nail size nuggets in the creeks. According to Mullison (1909) (an early prospector in the Medicine Bow Mountains), in 1870 some Ute Indians described several ancient prospects in the upper North Brush Creek basin. Mullison investigated these prospects in 1886 and found several diggings no more than half a mile apart on North Brush Creek, Cortez (also known as Cortex) Creek, and Mullison Creek (named in honor of the prospector).

Mullison described these diggings as relatively old prospects possibly dug by the Spanish. At one location near the mouth of Cortez Creek, Mullison reported that a 67-foot-deep shaft sunk in 1886 intersected some older mine workings that contained a tunnel and a 4-foot diameter shaft. The workings were in very poor condition, but before leaving, Mullison found an artifact of a face carved in "elk's ivory" on the floor of the mine. This was in the SW section 34, T17N, R81W (**Locality 34**). Similar workings were also reported to the southeast in sections 10 and 11, T16N, R81W, along Mullison Creek (**Locality 33**). Duncan (1990) suggested that it was possible that some of these prospects were dug by Forty-niners on their way to the the California gold rush.

In the same area (**Locality 33**), Mullison described an old stone wall along the creek, built to keep the steep bank from caving. Five separate prospects were found near the wall. A short distance from these prospects, Mullison found a 6-foot diameter circular shaft sunk in an abandoned part of the creek bed. Trees growing on top of the mine tailings were estimated to be more than 175 years old (Mullison, 1909, p. 32), suggesting the mine may have been of Spanish origin.

An article from the Saratoga Sun (Anonymous, 1932) reports on more interesting history for this area. Apparently, a prospector named Bradfield found an unusually rich gold placer in 1864, in the vicinity of Brush Creek (although the newspaper article reported that the prospect could instead have been in the Cedar Creek drainage). A cursory description of the surrounding area, stated that *the soil of this gulch was a gravel formation, red in color* (Anonymous, 1932) Bradfield dug through 8 feet of gravel before intersecting "slate" bedrock. The "slate" was cut by long, irregular crevices literally filled with gold flakes. In two days, Bradfield recovered 4 ounces of gold before being attacked by Indians. In a narrow escape, Bradfield abandoned his supplies and tools, including his pick and shovel. Upon returning to the area with

a group of well-armed prospectors, Bradfield searched in vain, but could not find the exact location of what became known as the "Lost Pick and Shovel prospect."

Locality 33
Mullison Creek

Mullison Creek and Lincoln Creek both have placer gold. Nearly every year, small quantities of gold, including tiny nuggets, are recovered from this area.

Locality 34
Cortez Creek placers

Cortez Creek (erroneously labelled as Cortex Creek on Forest Service maps) flows across Hanna Formation (Tertiary) conglomerates and drains into North Brush Creek. The drainage has been worked several times for placer gold (see **Locality 32**), as is evident from an old sluice and some hose fragments from a hydraulic mining operation (**Figure 29**).

Figure 29. The Boden long tom and sluice on Cortez Creek. Long toms were once commonly used in the Medicine Bow Mountains because of their ability to effectively separate gold and other heavy minerals from the prolific light weight minerals.

Upstream from locality 34, two placer diamonds were found on the Boden placer in 1977. The largest of the two was a translucent, clear octahedron weighing 1/10th of a carat (**Figure 30**). The source of the diamonds has not been found.

Figure 30. Placer diamonds from Cortez Creek found by Paul Boden in 1977. The larger diamond weighed 20.03 milligrams (0.1 carat) and the other diamond weighed 6.94 milligrams (0.03 carat). Scale is in millimeters.

Locality 35
Outcrop

On the north side of the road are prominent gray to pink outcrops of quartzofeldspathic gneiss. These rocks may represent the oldest rocks in the Medicine Bow Mountains and are assumed to be more than 2.5 billion years old. The gneiss is cut by a narrow, black, gabbro dike that can also be seen in the road cut.

Locality 36
Saratoga townsite and hot springs

The town of Saratoga is locally known for its hot springs and geothermal artesian wells. Breckenridge and Hinckley (1978) described several springs emanating from the Tertiary North Park Formation in the Saratoga area, although the geochemical characteristics of the water suggest a deeper aquifer is involved. The springs line up on a northeasterly trend, which strongly suggests they are fault controlled.

The best known of the springs is the Hobo Spring in the Saratoga Hot Springs City Park, where a masonry wall protects a dirt-floored spring from flooding by the adjacent North Platte River. The spring is accessible to the public at no cost. The water temperature measured in 1976 was 118°F (Breckenridge and Hinckley, 1978, p. 13).

Locality 37
Encampment townsite

Home of Wyoming's historic copper boom. Today, Encampment is primarily a logging town. The town includes the Grand Encampment museum which contains exhibits and has a wealth of information about the copper boom in the late 1800s and early 1900s.

The discovery of significant copper mineralization in the Sierra Madre in 1874 led to the development of the Doane-Rambler copper mine, but the most important discovery was made in 1897 when a prospector named Ed Haggarty found copper-stained quartzite north of the Doane-Rambler mine. Haggarty's prospect was later developed into the Ferris-Haggarty mine. A 16 1/4-mile-long tramway was constructed in 1902 to haul ore from the Ferris-Haggarty mine at about 9,700 feet elevation over the 10,690-foot high Continental Divide, and down the eastern slope of the Sierra Madre to the Boston-Wyoming mill and smelter located at Riverside at an elevation of 7,200 feet above sea level (**Figure 31**) (see **Locality 38**).

Some unfortunate events forced the closure of the Ferris-Haggarty mine even though the deposit was not mined out. First, the concentrating mill at Riverside was destroyed by fire in 1906. In the following year, a large part of the smelter was also destroyed by fire. The final nail in the coffin occurred in 1908, when the price of copper declined 35 percent from $0.20 per pound to $0.13 per pound.

Total production from the Ferris-Haggarty mine is not accurately known. However, the U.S. Bureau of Mines reported metal production from the Encampment mining district from 1898 to 1911 was 21,800,780 pounds of copper, 29,318 ounces of silver, and 2,237 ounces of gold (see Hausel, 1989, p. 152). Most of the metal production came from the Ferris-Haggarty mine.

The ore body at the Ferris-Haggarty mine averaged 6 to 8 percent copper with high grade ore carrying from 30 percent to 40 percent copper with some gold and silver. The deposit was described as 20 feet thick, occurring in quartzite breccia of the Magnolia Formation along the contact of hanging wall (overlying) schist and footwall (underlying) quartzite, and continuous downdip for at least 400 feet. In 1904, A.C. Spencer of the U.S. Geological Survey reported the extent of mineralization had not been determined.

Many years later, during the Second World War, the Ferris-Haggarty mine was investigated by the War Minerals Board and found to have large blocks of unmined low-grade ore (averaging 5 percent copper). This low-grade ore would be considered high-grade today. The historical mine workings were so extensive that the geologists had to make maps as they investigated the deposit so they could find their way out to the surface each evening (Ralph E. Platt, oral communication, 1989).

Locality 38
Riverside

Riverside is a small community next to the town of Encampment along the Encampment River. This was the site of the Boston-Wyoming smelter and concentrating mill that processed ore from the Ferris-Haggarty copper mine. A tramway was built from the Ferris-Haggarty mine to the smelter and had a daily haulage capacity of 984 tons, whereas the smelter had a maximum daily capacity of only 500 tons of ore (**Figure 32**). Today, nothing remains of the smelter and concentrating mill.

Figure 31. A 1903 view of part of the historical 16 1/4-mile-long tramway that connected the Ferris-Haggarty copper mine to the Boston-Wyoming smelter at Riverside. (Photograph from the University of Wyoming's American Heritage Center, S.H. Knight collection. Reproduced with permission.)

Locality 39
Purgatory Gulch

In 1897, the Chicago Herald reported a gold rush following the discovery of gold in the Purgatory Gulch area of the Encampment district (Larson, 1990). A few years later Henry C. Beeler, Wyoming State Geologist, reported *some remarkably rich gold specimens were found here* (Beeler, 1905).

The Purgatory Gulch area lies south of the town of Encampment. The area itself is accessible by a steep jeep trail designed for 4-wheel-drive vehicles a short distance from a graded road. Several small gold mines and prospects are found in the gulch and on the adjacent hillsides. In 1989, the author collected a grab sample of quartz containing visible gold from a mine overlooking the Encampment River on top of the hill west of Purgatory Gulch. A general rule of thumb is that if you can see visible gold in quartz, the sample will generally assay at least 1.0 ounce per ton gold. A second sample with pyrite in quartz was assayed yielding 0.55 ounce per ton gold, 0.12 ounce per ton silver, and 0.01 percent copper (Hausel, 1989, p. 157-158).

A quarter of a mile upstream from the mouth of Purgatory Gulch, where it is intersected by an unnamed gulch, are the remains of a few log cabins. This ghost town was once the home of the miners who worked in Purgatory Gulch.

Locality 40
Big Creek mining district

A few small mines and prospects were developed on copper-bearing and rare-earth-bearing pegmatites in the Big Creek mining district. The pegmatites are hosted by layered gneiss and schist.

Figure 32. The Boston-Wyoming copper smelter at Riverside as it appeared in 1902. The Encampment River is in the lower right corner of the photograph. In 1906, part of the concentrator was destroyed by fire, and in 1907, much of the mill and smelter were also destroyed by fire. These events, followed by a 35 percent drop in the price of copper in 1908, forced the closure of the Ferris-Haggarty mine even though large tonnages of copper ore remained unmined. (Photographs from the J.E. Stimson collection, Wyoming State Museum. Reproduced with permission.)

Locality 41
Big Creek mine

The Big Creek mine is in a 15- to 20-foot wide, copper-bearing feldspar pegmatite traceable on the surface for 2,400 feet. The pegmatite is exposed in the canyon rim along Big Creek; 70 feet below the rim, the pegmatite contains chalcopyrite, bornite, chalcocite, malachite and chrysocolla (Houston, 1961).

Locality 42
Platt mine

The Platt mine was developed in a 70- by 160-foot thick rare-earth-bearing pegmatite. The pegmatite (which is a coarse grained granite) consists of feldspar, mica, quartz, and rare earth minerals. It is exceptionally rich in rare earths and yielded 10,000 pounds of euxenite from 1956 to 1958 . In addition to euxenite, the pegmatite has some other rare earth element-bearing minerals, notably monazite and columbite (Houston, 1961).

Locality 43
Natures Mint mine

The Natures Mint mine, a historical gold mine along Boat Creek, is accessible from Forest Service Road 512. The mine workings continue across the road following a narrow quartz vein. During one recent study, McCallum and Kluender (1983) selected a sample of quartz from this vein that assayed 23.3 ounces of gold per ton!

Locality 44
Keystone mining district

This district lies along Douglas Creek in the vicinity of the village of Keystone. The district is accessible by Forest Service Roads 500 and 542 west of Albany. Albany can be reached via State Highway 11 about 5 miles east of Centennial. The Keystone village originally included several mine employee cabins and support buildings (**Locality 45**). Some of these early structures have been converted into summer cabins.

Several active gold mines and a few copper mines were centered in the district in the late 1870s (Hausel, 1989). The principal lode was the Keystone-Florence mineralized trend which extended from the village of Keystone to the Florence mine, nearly a mile to the southeast. The Keystone mine was sunk on the northwestern end of this trend and the Florence mine was developed on the southeastern end. Mineralization along the trend varied from trace to anomalous amounts of gold, with ore shoots located at either end of the lode.

The geology of the district is dominated by a large, circular, 5-mile diameter, quartz diorite pluton that intrudes quartz biotite schist and amphibole gneiss. The principal ore bodies are found in tensional shears (faults) subsidiary to the Mullen Creek-Nash Fork shear zone (Currey, 1965). These mineralized shears range in thickness (width) from a few feet to local splays over 300 feet (Loucks, 1976).

Locality 45
The Keystone mine

The Keystone lode was originally staked in 1876 and later developed into a mine. The shaft was sunk in quartz biotite schist along the northwestern flank of the Keystone quartz diorite. Available reports estimate about 5,000 ounces of gold were recovered from the mine before operations ceased in 1893 (**Figure 33**).

At the time of its closure, the shaft was 365 feet deep with more than 5,000 feet of drifts. It was reported in 1893 that 6,000 tons of ore sat on the dump awaiting processing, and 100,000 tons of reserves had been identified in the mine workings. The Keystone ore reportedly averaged 1.2 ounces per ton gold; thus, the identified reserves when the mine closed could have included as much as 127,200 ounces of contained gold.

Cleanup operations around the mine and mill occurred between 1916 and 1939, and the mill was dismantled in the 1950s (Currey, 1965). Sometime during this period, much of the remaining ore on the dump was probably processed, since there is very little of the ore currently found on the mine dump.

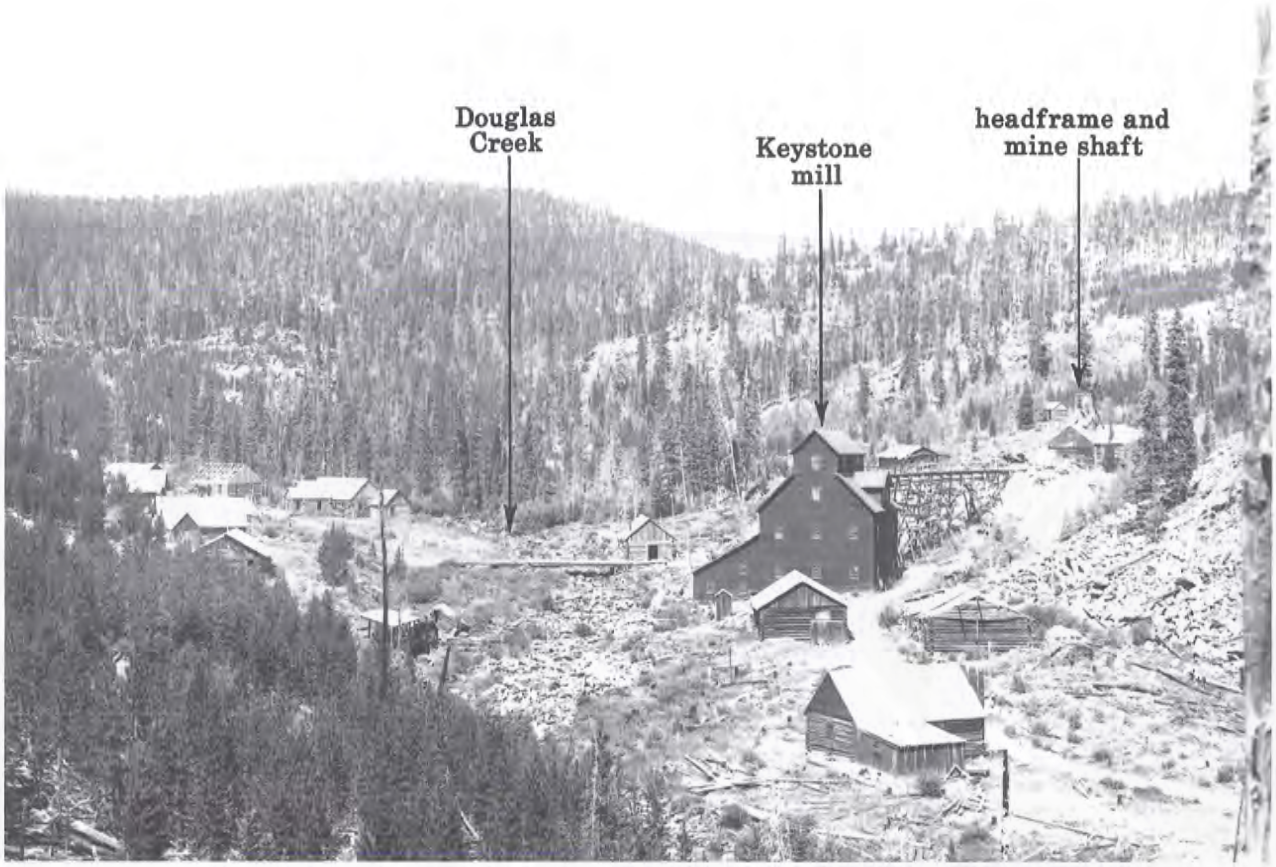


Figure 33. Historical Keystone gold mine and mill. A small headframe situated over the mine shaft, to the right of the mill behind a cabin, was used to haul ore to the surface. Immediately left of the five-story mill building is the Douglas Creek drainage. (Photograph from the University of Wyoming's American Heritage Center, S.H. Knight collection. Reproduced with permission.)

Some gold, however, is still found in this region each year. In the mid-1970s, Loucks (1976) collected samples from the Keystone mine that assayed from 0.19 to 8.75 ounces of gold per ton. More recently, samples collected by the author from the mine dump and in the Keystone shear zone yielded none to 0.64 ounce of gold per ton.

Locality 46
Florence mine and ghost town

Located at the southeastern end of the Keystone trend, the Florence lode is entirely within Keystone quartz diorite. The lode claim was not recorded until 1882, although the mine was presumably worked prior to that time (Duncan, 1990, p. 109). According to Currey (1965), the Florence mine produced an estimated 2,500 ounces of gold.

The available reports indicate the Florence had pockets of pyrrhotite (iron sulfide) with considerable gold. These sulfide "kidneys" contained as much as 7.5 to 48 ounces of gold per ton (Currey, 1965). This was more or less verified by Loucks (1976) who collected samples from the property that contained from 0.06 to 23.3 ounces of gold per ton. The author also collected samples from the Florence mine that varied from none to 1.3 ounces of gold per ton. One small boxwork sample with several visible specs of gold was not assayed but was instead, donated to the owner of the mine property. Based on the amount of visible gold in the sample, it would have undoubtedly assayed several ounces of gold per ton.

Today, the remains of several abandoned cabins at the Florence mine site are all that remain of a former townsite. According to Duncan (1990, p. 115), as many as 30 people lived at the Florence mine townsite in 1878. The town also included a boarding house known as the Miners Hotel.

Locality 47
Gold Crater mine and ghost town

Behind (north of) the Forest Service work center along Forest Service Road 542 are several old mines including the Gold Crater shaft. The shaft was sunk in the southeastern edge of the Mammoth trend; about 3/4 mile to the northwest on the same trend is the Independence copper-gold mine. The Gold Crater lode consists of several sheared quartz veins containing pyrite, chalcopyrite, and free gold.

Seven samples collected from mines in the Gold Crater Group by the Geological Survey of Wyoming contained none to 0.03 ounce per ton gold, and none to 0.55 ounce per ton silver. Two samples yielded 0.04 percent and 0.2 percent copper, and two other samples had 0.025 percent and 0.032 percent cobalt. The assays indicate the rock is weakly, although anomalously, mineralized.

A short distance west of the Gold Crater mine are the remains of several cabins and associated artifacts belonging to an old mining town.

Locality 48
Douglas mine and dredge tailings

Forest Service Road 543 from Keystone to Rob Roy Reservoir runs directly over the now buried 150-foot-deep shaft of the Douglas mine (**Figure 34**). This shaft was sunk on a mineralized vein reported to be 7 feet wide on the 35-foot level. Native copper, malachite (copper carbonate), chalcopyrite (copper-iron sulfide), chalcocite (copper sulfide), cobaltite (cobalt-iron sulfide), and gold were all found in the vein. At deeper levels, the vein split into three veins (0.5 to 2 feet, 2 to 3 feet, and 1-foot thick, respectively) (Currey, 1965). The presence of cobaltite is especially interesting. Cobalt is rare in the United States and is a critical strategic metal with important applications in high-tech jet fighters and in missiles, including the Patriot missile.

East of the former Douglas shaft are dredge tailings piled along Douglas Creek that mark the site of the Moe Brothers 1958 dragline and floating washing plant placer gold operation. The Moe Brothers Gold Run placer is actually part of the Douglas Creek placer mining district (see **Locality 49**).

Locality 49
Douglas Creek placer mining district

Douglas Creek begins near Willow Park south of Libby Flats and flows south through Rob Roy Reservoir and the Keystone district for several miles before swinging northwesterly and draining into the North Platte River. This creek and many of its tributaries cut across gold and platinum lodes and tend to concentrate precious metals into pockets or paystreaks in the stream bed. The district, which covers many miles of streams, was initially called the Foley district, but was renamed the Douglas Creek placer mining district in 1876 (**Figure 35**) (Duncan, 1990, p. 107).

Gold was probably discovered in the Medicine Bow Mountains in the early to mid-1800s; however, it was the discovery of gold by Iram Moore in 1868 on what later became known as Moores Gulch that attracted attention to the Douglas Creek region (**Locality 50**). By 1876, an elaborate network of ditches had been constructed and hydraulic operations commenced at several locations. Deep scars were cut in the drainages using hydraulic mining, and in places, the gravels were as much as 25 to 30 feet thick.

Natural reclamation through time has removed nearly all evidence of these early (pre-1900) placer mining operations. Occasionally, evidence of an early flume is found, but many flume remnants in the district were part of an extensive flume network related to logging rather than mining (see Thybony and others, 1985, p. 65).

The Douglas Creek placer district has yielded small amounts of gold nearly every year since Moore's original discovery. Total gold production is inaccu-

Figure 34. The Douglas mine as it appeared in 1905 viewed from a bridge over Douglas Creek. Ore froom the mine contained copper, gold, and cobalt. (Photograph from the University of Wyoming's American Heritage Center, S.H. Knight collection. Reproduced with permission.)

rately known, but is estimated at about 4,000 ounces for the pre-1965 mining operations in the district (Currey, 1965). Production of gold since 1965 has been minimal and probably totals less than a few hundred ounces.

Minor quantities of platinum and palladium flakes and nuggets (silver metallic, malleable metals with high specific gravity) have also been reported in some of the placers in the district. Scheelite (an important source of the strategic metal tungsten, which is used to strengthen steel) has also been identified in the district in recent years. Scheelite is a milky white, fluorescent (light blue under short wave ultraviolet light), heavy mineral that is difficult to pan out of a gold pan.

Statistics on the size and weight of gold nuggets from the district are lacking, although the largest reported gold nugget was a 3.4-ounce nugget discovered prior to 1906. Every summer, a small amount of gold, including nuggets weighing generally less than 1 ounce, is recovered by hobbyists.

There is evidence of some of dredging operations from the 1930s to the 1950s along Douglas Creek. One of the more interesting areas includes the south side of Moores Gulch near the original gold discovery site where the remains of a small revolving bucket dragline are found. About one half mile south of Rob Roy Reservoir on Douglas Creek are some dredge tailings from a 1958 dredging operation (see Locality 48). Probably the best place to view some dredge tailings is at the Bobbie Thomson campground (**Locality 52**) south of Keystone. The unmined gravel adjacent to the tailings underlying the campground still contains gold. Another place to see dredge tailings is at the Pelton Creek campground (**Locality 53**).

Figure 35. Circa 1905 steam shovel along the side of a long tom (sluice box) on the Home placers in the Douglas Creek mining district. The largest nugget discovered prior to 1906 was a 3.4 ounce pebble of gold found on the Home placers (see Hausel, 1989, p. 107-108). (Photograph from the University of Wyoming's American Heritage Center, S.H. Knight collection. Reproduced with permission.)

Locality 50
Moores Gulch

This was named after Iram Moore, who discovered gold here in 1868. Moores Gulch, including the area of Douglas Creek now under the Rob Roy Reservoir, became known as the Last Chance gold placers. During the first year of heavy prospecting (1869), as much as 400 ounces were recovered from this area (Hausel, 1989, p. 105).

A small village known as Cinnabar City was sited at the mouth of Moores Gulch (Duncan, 1990). But when Rob Roy Reservoir was constructed and filled with water from 1962 to 1965, this historical ghost town was submerged and lost forever.

In the 1980s, the reservoir was drained, dredged, and expanded. At that time, no effort was made to recover gold or platinum from the gravels and sediments (recovered from the historical placers) which were used to expand the dam. It has been said by more than one prospector that this dam might be "worth its weight in gold!"

Locality 51
Douglass City

In 1878, a town named Douglass City was built near the confluence of Douglas Creek with Little Beaver Creek to house many of the placer miners operating claims on Douglas Creek. The town had as many as 200 inhabitants in 1879 (Duncan, 1990). Only a few summer cabins remain from this once thriving village.

Locality 52
Bobbie Thomson campground

This Forest Service campground lies adjacent to Douglas Creek where extensive placer mining of the creek occurred sometime during the first half of the 20th century (**Figure 36**). Some of the dredged ponds presently provide good fishing holes.

Locality 53
Pelton Creek campground

There are more dredge tailings near the Pelton Creek campground. To get to these, drive about 8 miles northwest on Forest Service Road 898 (turn north from State Highway 230 about 2 miles west of Mountain Home at the Colorado-Wyoming border). The tailings lie a short distance downstream from the campground on Douglas Creek. From the campground, follow the hiking trail north of the campground, cross the footbridge to the other side of Douglas Creek, and within a few hundred yards downstream are the old tailings from an early placer gold mining operation.

Locality 54
New Rambler district

West of Rob Roy Reservoir and Douglas Creek is one of the only mining districts in North America that recorded historical platinum and palladium production. In addition to these metals, copper, gold, and silver were also mined.

The New Rambler mining district lies on the northeastern edge of the Mullen Creek mafic complex, a highly deformed, 60-square-mile, layered igneous complex similar to the Lake Owen complex to the southeast (**Locality 63**). The ore was localized in shear zones associated with altered rock. The principal rocks found in the area are amphibolite, granite, and biotite-plagioclase gneiss.

Locality 55
New Rambler mine and Holmes ghost town

The New Rambler mine workings lie immediately south of Forest Service Road 500 just west of the Holmes campgound. Much of this land is privately owned rather than administered by the U.S. Forest Service.

Shortly before the turn of the century, the New Rambler mine was developed as a gold prospect (**Figure 37**). But in 1900, copper was found at 65 feet below the surface. In the following year, platinum was detected in the copper ore after nearly 4,000 tons of the high-grade copper ore had already been shipped to a smelter (McCallum and Orback, 1968).

Figure 36. Dredge tailings in Douglas Creek at the Bobbie Thomson campground are from a gold mining operation in the historical past. Most dredges constructed around the turn of the century were poorly designed and typically rejected some gold with the unmineralized rock. Because of this, many dredge tailings still contain gold particles as well as some nuggets and are good places to prospect with a metal detector.

The mine operated periodically from 1900 to 1918 until the mill and mine buildings were destroyed by fire. In total, the operation produced at least 6,000 tons of copper ore that also carried values in gold, silver, platinum, and palladium. Much of the ore was high-grade concentrates from a supergene enriched zone at relatively shallow depths. About 4,000 tons of this ore averaged 25 to 30 percent copper (McCallum and Orback, 1968). This would suggest a minimum of 2.0 to 2.4 million pounds of copper were recovered during the lifetime of the mine.

Available records of the U.S. Bureau of Mines (1942) suggest production from the New Rambler mine amounted to a minimum of 1.75 million pounds of copper, 7,350 ounces of silver, 170 ounces of gold, 170 ounces of platinum, and 450 ounces of palladium. In contrast, Silver Lake Resources, Inc. (1986) estimated platinum group metal production at 910 ounces of platinum and 16,870 ounces of palladium. This latter estimate includes platinum group metals assumed to have been lost at the smelter prior to their discovery in 1901. Additional work in this area in the last 50 years suggests there could be additional platinum ore in this region.

The platinum and palladium metals were found in covellite (iridescent blue to black metallic copper sulfide), pyrite, and in a rare mineral known as sperrylite (silver gray, metallic, platinum arsenide). Sperrylite is found at only a few other localities in the world, and good specimens of the rare octahedron are nearly priceless to mineral collectors.

Platinum and palladium are strategic metals used in the electonic, chemical, and medical industries, and are also used in jewelry. They are a necessary component in catalytic converters used in automobiles to reduce emissions of carbon monoxide, hydrocarbons, and nitrogen oxides.

The New Rambler mine is situated in sheared (faulted) mafic and ultramafic rock at the northeastern edge of a layered mafic complex similar to the layered mafic igneous complexes in the Bushveld of South Africa and the Stillwater of Montana, where much of the world's platinum is currently mined. The complex hosting the New Rambler mine is relatively small (60 square miles) and young (1.8 billion years old) when compared to the Bushveld (33,000 square miles), and the Stillwater (2.7 billion years old).

The ghost town of Holmes lies east of the New Rambler shaft. Prior to the spring of 1991, several decaying log cabins remained in the forest east of the mine tailings.

Figure 37. View of the New Rambler mine and tailings as they looked in 1979. Trees in the area were used by the early miners in the construction of mine buildings, living quarters, and for supports in the extensive underground workings.

Locality 56
Blanche mine

The Blanche shaft is located 600 to 700 yards west of the New Rambler mine, and lies in the forest along a dirt road west of the New Rambler mine. The Blanche shaft was an exploration shaft developed to find the western extent of the New Rambler ore body. It was sunk to a depth of 160 feet, and at a depth of 120 feet, the shaft penetrated a zone of low-grade copper mineralization.

The rocks encountered in the mine included gneiss, metagabbro, and metadiorite similar to those in the New Rambler mine. The mineralization occurred as milky quartz with bronze-colored, metallic pyrite; chalcopyrite; black, massive chalcocite; and bright green copper carbonate.

Locality 57
Lake Creek

This locality is about 5 miles northwest of Foxpark on Forest Service Road 512. The Lake Creek village on Lake Creek is a small community of summer cabins. A few old mines and prospects are visible in this area including the Lake Creek copper mine located at the apex of the hill north of the village.

Locality 58
Many Values pegmatite prospect

The Many Values prospect consists of two small prospect pits covered by decaying cabins (**Figure 38**). This locality (E2 section 32, T13N, R78W) is about a mile west of State Highway 230 between Woods Landing and Mountain Home. The main pegmatite is exposed on the surface for 140 feet. This pegmatite contains abundant muscovite mica with quartz and feldspar. Other less common minerals include beryl (a beryllium oxide), garnet, small tantalite crystals, and some black tourmaline (schorl) (Osterwald and others, 1966, p. 132). In 1942 and 1943, some mica, beryl, and tantalite were mined from this prospect.

Locality 59
American copper mine

Not much is left of this mine located within walking distance of Forest Service Road 526 southeast of Mountain Home. The shaft has been filled and buried, but samples of copper-stained granite can still be found around the old workings. One recently collected sample of granite from the mine site, stained with malachite and azurite (green and blue copper carbonates), assayed 1.4 percent copper and 3.0 ounces per ton silver (Hausel and Jones, 1984).

Figure 38. An old cabin with a headframe built into its roof over part of the Many Values pegmatite prospect as it appeared in 1984.

Locality 60
Jelm Mountain mining district

The historical Jelm Mountain (Bramel) mining district lies in the foothills of the Medicine Bow Mountains along the Laramie River south of Woods Landing. Based on geology, the district is defined from Jelm Mountain westward across the Laramie River (**Plate 1**). The historical Old Jelm (Cummings City) townsite (**Locality 61**) lies on the west bank of the Laramie River, where the remains of the ghost town are clearly seen from State Highway 10 (**Figure 39**). Only minor amounts gold and copper were recovered from the district.

In 1872, the Bramel mining district was organized (Michalek, 1952). Gold was discovered in narrow, copper-stained, gossans hosted by amphibolite schist and gneiss. Small amounts of gold were also found in placers in the Laramie River. All of the mineralized lodes were very narrow veins, shears, and rehealed faults.

Some exaggerated claims about the value of the lodes led to their promotion. In 1876, for example, a sample from the Sunrise mine on the southeastern flank of Jelm Mountain was reported to assay 27 ounces of gold per ton with 950 ounces of silver per ton (Duncan, 1990). It is possible that a small, select, hand sample from the mine could have assayed relatively high in gold, but the silver content is highly improbable.

Interest in the district was further stimulated through apparently grossly exaggerated claims made by two promoters, John Cummins and P.T. Smith. Duncan (1990) reported that in 1880, these two individuals claimed several samples from the district assayed from 1,780 to 3,480 ounces of gold per ton. In that same year, a local newspaper reported *an expert who has visited Cummins City says the boom there is a fraud, and that the Mill Creek carbonates were brought from Leadville.*

Figure 39. The Cummings City (Old Jelm) ghost town located west of Highway 10, about 4 miles south of Woods Landing. (Photograph from Hausel and Jones, 1984.)

Undoubtedly, people were already questioning the exaggerated claims about the Bramel mining district. But, it should also be realized that in 1880 it was impossible to identify the source of the ore. Even with modern, detailed, geochemical analyses and techniques, it would be difficult to prove where the sample originated. It is also interesting that the newspaper story mentioned "carbonates", because the known Jelm Mountain deposits are primarily quartz veins and shears hosted by schist, granite, and gneiss, rather than carbonates.

In 1880, plans were drawn for the town of Cummins City along the Laramie River. In that year, the town reportedly had 100 houses and a population of 300. Additionally, Cummins City was reported to have had 4 saloons, 5 stores, a library, three stamp mills, and a public meeting hall (Duncan, 1990). Conflicting reports claim the boomtown had a maximum of 30 buildings and a population that did not exceed 50. One of the structures that apparently did exist was a two-story, 40-room hotel, which was later moved to Laramie sometime after the Jelm Mountain gold and copper booms (Wyoming Recreation Commission, 1976).

By the end of 1882, the gold boom was over, but Cummins City continued to survive as a stage stop (Duncan, 1990). In 1896, the district again came to life with more exaggerated claims of the size of Cummins City and the promotion of the copper found in the gold lodes. The Bramel mining district was also renamed the Jelm mining district.

But copper found in association with the gold occurred in tonnages too small for commercial mining. There were reports of samples of ore assaying as high as 30 percent copper, but again such samples would have been spatially restricted. Without the development of any major mines in the district, Cummings City slowly disappeared.

Today, only about nine structures remain at the site of the historical boomtown (**Figure 39**). On the south side of Jelm Mountain along the observatory road (**Locality 62**), one can still see some of the historical mine workings. Samples of copper ore occur on the dumps and in the lodes. The most common minerals are chalcopyrite (bronze-colored, copper-iron sulfide), tenorite (jet black copper oxide stain), chrysocolla (azure blue copper silicate), and malachite (a green copper carbonate stain).

Locality 61
Old Jelm (Cummins City) ghost town

See **Locality 60** for discussion.

Locality 62
University of Wyoming's observatory

The Jelm Mountain observatory on top of Jelm Mountain is the home of the University's 92-inch infrared telescope. Tours of this facility can be arranged during the summer months through the University of Wyoming.

Locality 63
Lake Owen

Lake Owen and the Lake Owen campground lie along the northern edge of the Lake Owen layered mafic complex. This complex is similar to the Mullen Creek complex in the New Rambler district (**Locality 54**), although the Lake Owen complex is essentially undeformed. The Lake Owen complex is approximately 1.8 billion years old and covers an area of 25 square miles.

In recent years, 12 stratigraphic horizons in the Lake Owen complex have been identified with cumulate sulfide mineralization similar to the Stillwater complex in Montana, where the strategic metals platinum, palladium, and chromium are mined. Four of these horizons at Lake Owen have laterally persistent zones with anomalous concentrations of gold, platinum, and palladium that warrant further investigation. In addition to precious metals, anomalous chromite and persistent layers of vanadiferous magnetite-ilmenite occur in the Lake Owen complex (Loucks, 1991). The vanadiferous magnetite-ilmenite layers are considered potential sources of the strategic metals vanadium and titanium, and also have significant amounts of iron and some copper (R.R. Loucks, Purdue University, oral communication, 1991).

Locality 64
The Little Laramie oil field

A short distance west of Interstate 80 at the Herrick Lane overpass is the Little Laramie oil field in the flood plain of the Little Laramie River. This field was discovered in 1948 by Superior Oil Company. The oil is produced from the Casper Formation at a depth of 3,700 feet (Hausel and Jones, 1984).

Locality 65
Quealy Dome oil field

In the foreground south of Interstate 80, is the Quealy Dome field. Oil, which was discovered here in 1934, is recovered from the Muddy Sandstone and sandstones in the "Dakota" (Cloverly), Sundance, and Casper Formations (Hausel and Jones, 1984).

Locality 66
Cooper Hill district

The Cooper Hill district lies south of Interstate 80 along the northeastern slope of the Medicine Bow Mountains and includes a bald (treeless) hill known as Cooper Hill easily seen from Interstate 80. Access to the district is privately controlled and permission is required from the surface owner.

Gold, silver, lead, and copper lodes were discovered in this area after mineralized float was discovered along Cooper Creek in 1893 (Schoen, 1953). This district was originally included in the Herman mining district (Duncan, 1990), but currently is known as the Cooper Hill district.

From 1893 until 1897, several mines recovered some ore in the district. In 1896, the town of Morganville (later changed to Morgan) was laid out at the southern end of Cooper Hill and included a saloon, hotel, and several cabins (Duncan, 1990). In 1897, according to Duncan (1990), a 10-stamp mill was built to process ore stockpiled from the previous years, but recovery of metals from the mill was much less than anticipated and the district was soon deserted. Unfortunately, stamp mills were designed to extract easily recoverable gold with some silver. Because the ore from Cooper Hill included lead, silver, copper, and antimony in addition to gold (Schoen, 1953), many of these valuable metals were probably lost to the tailings.

Recent investigations by the Geological Survey of Wyoming identified copper-bearing skarns, silver- and lead-replacement deposits, and some veins. The skarns are formed of minor amounts of pyrite, chalcocite, and chalcopyrite in epidote-chlorite-magnetite-actinolite-garnet-calcite hornfels and represent altered limestones. The silver- and lead-replacement deposits contain argentiferous (silver-bearing) galena, polybasite, common pyrite, and gold and also occur in altered limestones.

Mapping by Hausel (1992) and by Schoen (1953) has shown that the district occurs in a folded succession of Proterozoic age metamorphosed sedimentary and metavolcanic rock. These include metalimestone, mica schist, quartzite, quartz- and black chert-pebble metaconglomerate, and amphibolite. The amphibolites are interpreted to represent metamorphosed gabbro and basalt.

In 1991 and 1992, several sites along Cooper Creek were sampled and panned for gold. Nearly every sample collected in this area yielded anomalous concentrations of gold and visible gold colors. Even a sample panned from the sand and gravel in Cooper Creek adjacent to Interstate 80 produced some visible gold (Hausel and others, 1992).

Mining activity and mineral resources

In the past, the Medicine Bow Mountains supported several mining operations in which copper, gold, silver, platinum, palladium, and rare earths were recovered. And as recently as 1977, diamonds were found in the northern Medicine Bow Mountains by a gold prospector (Paul Boden) from Saratoga, Wyoming. Although none were very large, the placer operations of the Douglas Creek district were widespread and recovered moderate amounts of gold with some platinum. Other important metal production

came from lodes such as the Keystone, New Rambler, and Centennial mines.

At the time of the writing of this guide, no mines were operating in the Medicine Bow Mountains, and only a few hobbyists and part-time prospectors with small hobby-type dredges were recovering some gold and platinum from the creeks during the summer months (**Figure 40**).

The geology of the Medicine Bow Mountains suggests that there is a possibility for large undiscovered mineral deposits. For example, in the northern Medicine Bow Mountains there are thick successions of quartzites with radioactive quartz-pebble conglomerates which have many characteristics of the uranium-rich Blind River deposits of Canada, and the gold- and uranium-rich Witwatersrand deposits of South Africa (**Figure 41**). Similarities to these deposits could be very significant, particularly when one realizes that 52 percent all the gold mined in human history has been mined from the Witwatersrand conglomerates of South Africa.

In the central and east-central parts of the Medicine Bow Mountains are two large layered mafic complexes similar to both the Bushveld Complex in South Africa and the Stillwater Complex in Montana. These latter two complexes host most of the world's known reserves of platinum, palladium, osmium, ruthenium, iridium, and rhodium as well as significant amounts of chromium, vanadium, and gold. Thus, based on geological similarities, the Medicine Bow Mountains could contain valuable mineral resources of a number of important scarce strategic metals as well as precious metals.

Figure 40. Recreational gold prospecting in the Medicine Bow Mountains.

Prospecting and gold panning hints

While visiting the Medicine Bow Mountains, you may want to pan for gold or prospect for mineralized veins. (Seminars on prospecting and geology and prospecting tours of the Medicine Bow Mountains for groups can be arranged during the summer months through the Geological Survey of Wyoming.) In general, prospectors tend to speak of two forms of gold deposits–placers and lodes. Placers are stream sediments and gravels that carry some valuable minerals or metals that for the most part have been eroded from the bedrock and concentrated by fluvial processes. Lodes are in-place mineralized quartz veins, faults, or shear zones.

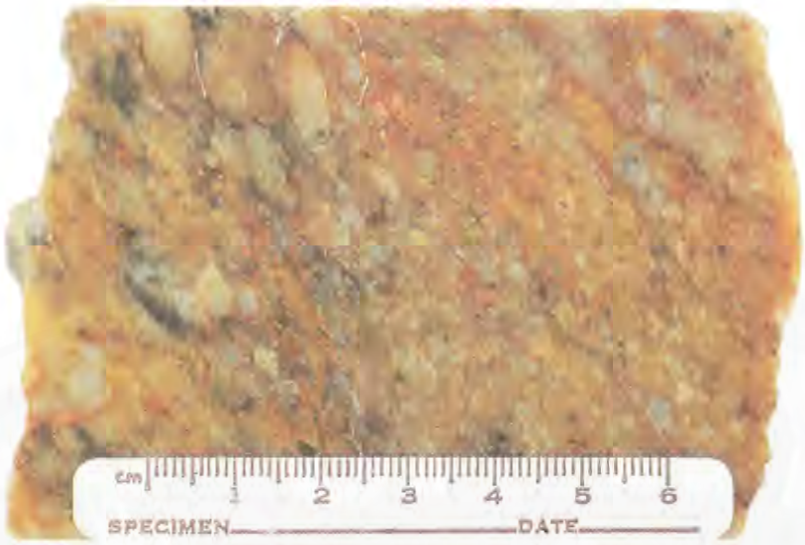


Figure 41. Drill core of radioactive metaconglomerate from the northern Medicine Bow Mountains. Conglomerates from the Medicine Bow Mountains and the Sierra Madre contain uranium, monazite, and some gold.

Within the boundaries of the National Forest, much of the land is open to casual prospecting and rock hunting with the exception of private land, lands withdrawn from mineral activities, and areas that are already staked by other prospectors or mining companies. If you have questions regarding access or areas open to casual prospecting, contact the local and State offices of the U.S. Forest Service or the U.S. Bureau of Land Management.

Panning for gold and platinum is relatively easy particularly if you have the proper equipment. Although all you need is a gold pan, you will find some of the following equipment useful as they will make your panning life a lot easier: a good shovel, a magnifying lens, rubber boots, a gold pan (plastic gold pans are preferable), and a grizzly pan (or fly screen). Since gold is very heavy, it will concentrate at the bottom of the stream gravels. Thus the deeper you dig, the better your chances of finding gold.

The better areas in the creeks occur along stream meanders, behind boulders, or any place where the water velocity slows noticeably. Dig some material and place it on your screen or grizzly pan. Wash the material through the screen into your gold pan and discard the pebbles on the screen. Next, take your gold pan and tilt it about 30 degrees into the stream keeping the lower lip under the water while swirling in a circular motion. You will begin to see many of the lighter minerals float out. Continue panning until the concentrate is black. This is the black sand prospectors often refer to. Don't worry about losing the gold. If you are retaining the black sand, there is little chance of losing the gold. Gold has a specific gravity of about 19.3 (19.3 times heavier than water), the black sand has an average specific gravity of only 4.0, and many of the lighter-colored minerals you already washed out have an average specific gravity of only about 2.8.

Now examine the black sand. Look for flakes and nuggets of warm yellow metal. This metal is malleable, meaning that you can take a pin and easily dent the metal. Some people confuse mica with gold; however, the mica will tend to spin (roll) in the water when swirling the gold pan (gold will not), and small pieces of the mica will flake off under the pressure of a pin point. Gold flakes and nuggets can be picked out with your fingers. The very small gold colors the size of a pin point can be recovered by first removing the water from the pan. Then, by wetting your index finger and touching these colors, they can be removed.

The author has panned gold from several places along Douglas Creek near the Bobbie Thomson campground, and on most summer days prospectors with small portable dredges can be found along the creek recovering flakes and nuggets. These people generally have mining claims in this area, so if you want to pan on their claims, you must obtain their permission.

In 1991 and 1992, the Geological Survey of Wyoming sampled several creeks along the northern flank of the Medicine Bow Mountains (**Figure 42**). Using just a gold pan and a shovel, we were able to find visible gold (generally tiny gold colors) at nearly every creek and sand and gravel deposit in this region. At sample site (1), some gold colors were recovered from a State of Wyoming public fishing area. At site (2), visible gold, including a small nugget, was recov-

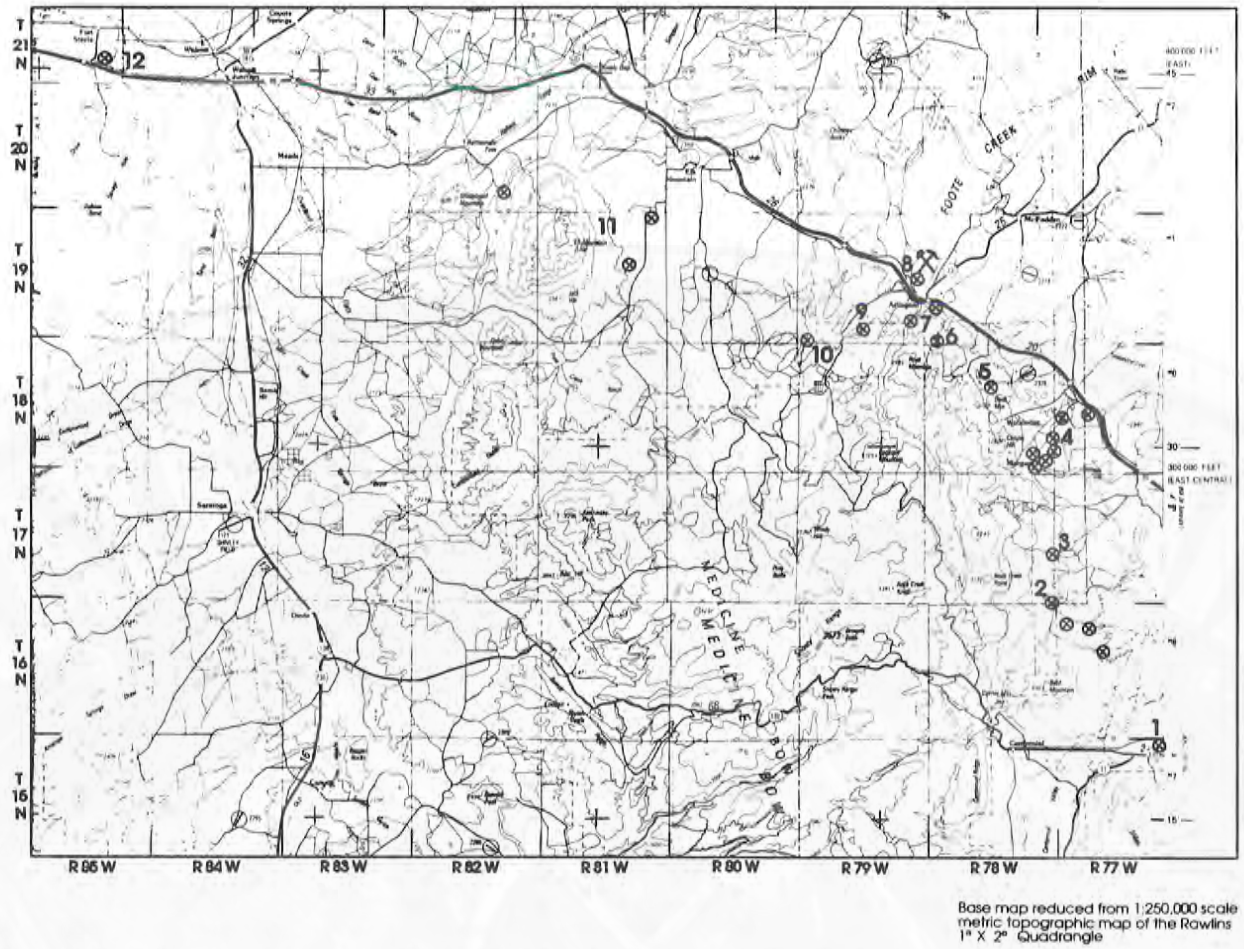


Figure 42. Sample location sites along the northern Medicine Bow Mountains. Numbers indicate sample localities described in the text.

ered from the Mill Creek area. At (3), visible gold was recovered and the sample concentrates assayed 124 parts per million (ppm) gold (34.3 ppm=1 ounce per ton). Samples collected along Cooper Creek (4) yielded gold colors as far south as Morgan, and as far north as Interstate 80. At site (5), the sample concentrates from the West Fork of Dutton Creek contained visible gold and assayed 113 ppm gold. At (6), sample concentrates from Onemile Creek contained visible gold and assayed 87 ppm gold. Two samples in the Arlington area along Rock Creek (7) contained gold colors and both concentrates assayed more than 100 ppm gold. At (8), a few tiny gold colors were recovered from gravels from the historical Emigrant Gulch placer mine. This area was hydraulically mined in 1877 and in 1897. At (9), visible gold was recovered in a branch of Foote Creek. At (10), a branch of Foote Creek, visible gold was found and the sample concentrates assayed 256 ppm gold. Samples in the Elk Mountain area (11) yielded only trace amounts of gold. At Fort Steele (12), several samples yielded anomalous gold, but only one sample north of Interstate 80 yielded one tiny gold color. Access to some of these areas will require permission from private land owners.

Lode deposits are relatively easy to study once you understand what you are looking for. Visit one of the historical mine sites. Most of the shafts and tunnels were dug on veins. These veins tend to be linear in that many of them follow faults or deep fractures in the earth. Often the vein will be composed of milky white quartz with a lot of rusty material known as limonite, or will be a fault or shear zone where the rocks have been granulated (ground up) producing a gouge zone. Geologists tend to refer to such rocks as being "chewed up".

Follow the lode or its float (loose quartz sitting on the surface) as far as you can, being careful not to get lost since the forest can be quite dense and it is easy to get turned around. As you walk along the lode, look for distinct rusty looking spots, particularly lenses of rusty, vuggy to spongy looking rock. These are good places to look for gold. Use your magnifying lens to look for any gold. A rule of thumb is that if you can see gold under a 10-power magnifying lens in a rock, the sample will probably assay at least 1.0 ounce per ton. If you don't see any gold, you can check the sample by either sending it to an assayer, or crushing the rock with a hammer in a gunny sack and panning the pulverized material.

If you find something you're not sure of, or question your identification of gold, please feel free to visit the Geological Survey of Wyoming on the University of Wyoming campus in Laramie, or write to Geological Survey of Wyoming.

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Appendix A-Common geology, mining, and prospecting terms

Adit: A horizontal mine tunnel (see also shaft).

Anticline: A fold that is convex upward with the oldest rocks in the core.

Archean: see Precambrian.

Bioherm: A dome-like mass of calcareous rock built up by the remains of sedentary organisms such as corals, algae, and stromatoporoids).

Boxwork: Vuggy limonite residue left behind from the weathering of iron-rich minerals such as pyrite or siderite.

Dike: A narrow, linear, mass of igneous rock that often follows a prominent fracture in the earth's crust.

Fault: A fracture in which rocks have been displaced. Some types of faults include reverse, normal, and thrust. A thrust fault is a relatively low angle fracture in which older rocks have been displaced on top of younger rocks. A reverse fault is a high-angle thrust fault. A normal fault has the opposite sense of movement of a reverse fault.

Ga: Giga-annum or one billion years.

Gangue minerals (pronounced "gang"): The valueless minerals associated with a vein or ore deposit.

Gossan: An iron-rich (rusty appearing) zone formed of limonite and related minerals found over many sulfide-rich (pyrite, chalcopyrite) mineral deposits. Produced by oxidation and weathering.

Laramide orogeny: This was a major time of crustal deformation in the Rocky Mountains that culminated with the development of many of our present mountain ranges. This episode of deformation extended from the Late Cretaceous to the early Tertiary (about 120 million years ago to 55 million years ago).

Lode: In general, refers to a mineralized zone, quartz vein, or a mineral deposit occurring in a consolidated rock outcrop.

Metamorphism: The mineralogical and structural adjustment of solid rock to chemical and physical conditions imposed by elevated temperature and pressure at depth.

Mylonite: A compact chertlike rock produced by extreme granulation and shearing of rocks.

Ore: A naturally occurring material from which minerals of sufficient value or quantity might be (or were in the past) mined at a profit.

Ore shoot: An unusually rich aggregation of ore in a vein or shear zone (lode).

Paraconglomerate: A conglomerate that is not a product of normal aqueous flow but deposited by such modes as mass transport (slides, turbidity flows, and glacier ice).

Paystreak: A zone of rich mineralized gravel in a placer deposit.

Phanerozoic: Rocks younger than the Precambrian. Those that formed from about 570 million years ago to the present.

Placer: In general, refers to mineral deposits mechanically concentrated in streams and in stream-deposited terraces, associated fluvial deposits, and some beach deposits. Composed of materials eroded from bedrock.

Pluton: A large mass of igneous rock.

Precambrian: An important division of geological time that is a general term for rocks older than the Phanerozoic. Typically divided into the Archean Eon (3.8 billion to about 2.5 billion years ago) and the Proterozoic Eon (2.5 billion to 570 million years ago).

Proterozoic: see Precambrian.

Shaft: A vertical mine tunnel (see also adit).

Shear zone: A tabular zone of rock that has been crushed and brecciated with many parallel fractures.

Strategic mineral or metal: Metals and minerals that our country does not mine in sufficient amounts to supply the needs of our domestic industries or the military in case of a national crisis, such as a war, or an embargo. Nearly every metal found in nature is considered as strategic for the United States.

Sulfide: In reference to one of several metallic-sulfides such as pyrite.

Supergene enrichment: Refers to the solution of a metal from the upper part of an ore deposit by surface waters and its redeposition below (generally at the water table).

Vein: A zone or belt of mineralized rock lying within clearly defined boundaries that separates it from the enclosing host rock.

Appendix B-Selected rock and mineral definitions

Amphibolite: A dark gray to black metamorphic rock formed almost entirely of the prismatic amphibole minerals. Amphibolites typically represent recrystallized basalts, gabbros, or greywackes.

Arsenopyrite (arsenic-iron sulfide): A silver-gray metallic sulfide that alters to a yellow green stain known as scorodite. The mineral itself is of little value, although it often incorporates enough silver or gold to make it an ore mineral.

Basalt: A fine-grained, dark gray to black, mafic volcanic rock typically erupted onto the surface of the earth.

Beryl: Hexagonal (six-sided), green crystals typically found in pegmatites such as the Many Values pegmatite (**Locality 58**). Rarely, beryl occurs as a light blue, transparent to translucent gem known as aquamarine and as an emerald-green transparent to translucent gem known as emerald. Beryl (beryllium oxide) is a common ore for the metal beryllium, which is a strategic metal used in the electronic and aerospace industries.

Chlorite: A greenish mica.

Chalcocite: A copper sulfide ore mineral that is relatively heavy and generally earthy black.

Chalcopyrite: a bronze, metallic, copper ore mineral (copper-iron sulfide).

Chrysocolla: A beautiful, glassy, azure blue copper silicate.

Columbite: A black mineral oxide that is the principal ore of the rare earth element niobium, and also a source of tantalum. These high-tech metals have many important uses in alloys used in the electronics industry and aerospace industry.

Dolomite: A mineral, or a rock composed primarily of the mineral dolomite (calcium-magnesium carbonate).

Euxenite: A rare earth oxide containing tantalum, niobium, and yttrium (see also columbite). Yttrium, like the other rare earth elements is a high-tech metal used in the electronics industry, in lasers, and in superconductors.

Gabbro: A dark gray to black, medium- to coarse-grained, mafic igneous rock that is the subvolcanic and plutonic equivalent of basalt.

Garnet: A complex group of silicate minerals. There are a variety of garnets found in nature. In the Medicine Bow Mountains, garnets are often found as translucent to opaque, reddish-brown, equidimensional crystals known as dodecahedrons. They are common in schists, and are numerous in the stream beds as tiny red crystal grains. Since garnets are relatively heavy, prospectors typically find many garnets in their black sand concentrates when panning for gold.

Gold: A valuable precious metal. Native gold occurs as a warm, yellow, heavy, malleable metal.

Gneiss: A coarse-grained foliated metamorphic rock with alternating bands of light-colored and dark-colored minerals.

Granite: A coarse-grained, light-colored igneous rock composed primarily of pink and light-colored feldspar, gray quartz, and dark mica.

Greenstone: Refers to a metamorphosed igneous rock that is greenish in color.

Greywacke: A gray, micaceous sandstone.

Hematite (iron oxide): A soft, silver metallic to earthy red, nonmagnetic mineral.

Huttonite (thorium silicate): A colorless to pale-cream radioactive mineral that fluoresces white to pink under ultraviolet light.

Igneous: "Fire rock". A rock produced by the cooling of hot magma, either on the surface (volcanic) or at depth in the earth (plutonic).

Ilmenite (iron-titanium oxide): An important ore mineral for titanium (a strategic metal used in high performance civilian and military aircraft).

Limonite (hydrated iron oxide): A reddish-brown to yellowish-brown mineral formed as a weathering product of sulfide minerals. Typically found in gossans.

Mafic: Refers to dark-colored igneous rocks typically containing relatively high amounts of magnesium in silicate minerals.

Magnetite (iron oxide): Magnetite forms a black, equi-dimensional, highly magnetic octahedron. Generally found in large amounts in placers and forms much of the black sands referred to by prospectors.

Malachite (copper carbonate): Typically forms bright green stains, patina, and crusts on copper ores. It is the alteration product of many primary copper minerals such as chalcopyrite. May contain considerable amounts of silver in its crystal structure.

Mica (complex silicate): A platy (pseudo-hexagonal) mineral that forms in "books". In pegmatites, crystals can obtain large dimensions of several inches across. Can occur as white mica (muscovite), or very small white mica (sericite), black to brown mica (biotite), and dull green mica (chlorite).

Monazite: A wedge-shaped, yellowish to reddish-brown, generally weakly radioactive, phosphate of the rare earth metals cerium and lanthanum. Appreciable amounts of thorium and yttrium may substitute for the rare earth metals. This is a heavy mineral found in some placers with the black sands. The rare earth metals in this mineral are also considered to be strategic metals and have many important commercial and military applications and are extensively used in superconductors.

Phyllite: A fine-grained foliated metamorphic rock of sedimentary origin.

Platinum: A malleable, heavy, silver, metallic, precious metal. This critical strategic metal has important uses in jewelry, electronics, metallurgy, and has widespread usage in catalytic converters.

Pluton: An igneous intrusion that formed below the earth's surface. These rocks are typically coarse-grained (they cool and crystallize over relatively long periods of time) in contrast to volcanic rocks that erupt on the earth's surface and cool rapidly.

Pyrite (iron sulfide): Commonly known as fool's gold. A brass-colored, metallic sulfide that is often mistaken for gold. Pyrite, however, can incorporate large amounts of gold in its crystal structure. As much as 2,000 parts per million gold (60 ounces of gold per ton) can be hidden in the crystal structure. Generally, the fine-grained to massive pyrite carries some gold and the medium- to coarse-grained pyrite is barren of gold.

Quartz (silica): A common rock-forming mineral that forms a large portion of most veins.

Quartz diorite: A medium-grained, gray igneous rock common in the Keystone district (**Locality 44**).

Quartzite: A hard, granular, metamorphic rock composed mostly of quartz grains. The metamorphosed equivalent of sandstone.

Rutile (titanium oxide): A titanium ore mineral.

Schist: A distinctly foliated metamorphic rock. Generally, mica forms large portions of schist.

Schorl: Black tourmaline.

Siderite (iron carbonate): A brownish, rhombohedral gangue mineral found in many veins.

Skarn: Rock composed mostly of lime-bearing silicates derived from limestones and dolomites into which large amounts of silica, aluminum, iron, and and magnesium have been introduced.

Slate: A hard, black to dark gray, foliated metamorphic rock with the appearance of a chalkboard. The metamorphosed equivalent of shale.

Sperrylite (platinum arsenide): A tin-white, bright, metallic ore mineral of platinum occuring in masses, less often in cubes, and rarely in octahedrons.

Sphene (calcium-titanium oxide): An important titanium-bearing mineral with a relatively high specific gravity (relatively heavy) often found in black sands in placer deposits and in titaniferous black sandstone deposits (**Locality 5**).

Tantalite (an oxide of iron, manganese, niobium, and tantalum): A heavy mineral found in black sands in paystreaks of placer deposits and found in some titaniferous black sandstone deposits (**Locality 5**). Tantalum is a strategic metal with several important uses, including the manufacture of surgical instruments. Niobium is a strategic metal used in superconductors, and manganese is

a critical strategic metal used in production of virtually all steels.

Tourmaline: A prismatic silicate mineral with distinct triangular to hexagonal cross sections. In pegmatites such as the Many Values prospect (**Locality 58**), tourmaline occurs as long, narrow, jet black schorl in a white pegmatite matrix.

Ultramafic: An igneous rock with very high amounts of magnesium. These rocks are interpreted to have originated from the earth's mantle where minerals are also rich in transition elements such as chromium and nickel.

Zircon (zirconium silicate): A relatively heavy, reddish brown, translucent, prismatic crystal often found in black sand concentrates and in titaniferous black sandstone deposits (**Locality 5**). A primary ore mineral of the strategic metal zirconium. Zirconium is used chiefly in the facings of foundry molds, in refractory bricks for furnaces, and in the structural material in nuclear reactors. Zircon also contains appreciable amounts of hafnium, which is used primarily in the control rods of the U.S. Navy's nuclear reactors.

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