Gemstones and other unique minerals and rocks of Wyoming

A field guide for collectors

W. Dan Hausel and Wayne M. Sutherland

Reprint of 2000 edition

Wyoming State Geological Survey

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Wyoming State Geological Survey

Thomas A. Drean
Director and State Geologist

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Cover: Silicified banded iron formation from north of the Seminoe Mountains, south-central Wyoming. The specimen is about 4 inches high. *Photo by Jesse W. Sutherland (2010) and used with permission. Cover design by Robert Waggener, WSGS. Reprint compiled by Chamois L. Andersen, WSGS.*

WYOMING STATE GEOLOGICAL SURVEY
Thomas A. Drean, State Geologist

BULLETIN 71

GEMSTONES AND OTHER UNIQUE MINERALS AND ROCKS OF WYOMING

A FIELD GUIDE FOR COLLECTORS

by

W. Dan Hausel
and
Wayne M. Sutherland

Laramie, Wyoming
2014 - Reprint

TABLE OF CONTENTS

Page

Page

Page

FIGURES AND PLATES

Figure **Page**

Figure	Page

TABLES

ABSTRACT

Wyoming has some of the better rock exposures in the world, making the state an excellent place to collect rocks and minerals. Several new discoveries of gems, minerals, and rocks have been made in Wyoming in recent years, including diamond, iolite, peridot, komatiite, kimberlite, and many other rocks and minerals.

A very unusual and extremely rare rock type found in Wyoming is lamproite, a 1 to 3 million-year-old, ultrapotassic volcanic rock found in the Leucite Hills. The unique mineral assemblage of lamproite includes phlogopite, olivine, leucite, sanidine, potassium-richterite, diopside, apatite, anacite, spinel, priderite, wadeite, perovskite, shcherbakovite, and armalcolite.

Another group of rare potassic rocks known as kimberlite have been found in southeastern Wyoming. These serpentinized hybrid peridotite breccias contain several unusual minerals including chromian diopside, chromian enstatite, pyrope garnet, and sometimes diamond. Some peridotite and eclogite xenoliths found in kimberlite are also rare and are prized museum specimens. A few of the kimberlites have yielded gem-quality pyrope garnets, chromian diopsides, and some excellent transparent diamonds.

Corundum (including ruby and sapphire) has been found in several Precambrian vermiculite deposits. Other host rocks for corundum include quartzofeldspathic gneiss and serpentinite. Some large ruby specimens (2 inches across) have recently been found in quartzofeldspathic gneiss in the Granite Mountains. At another locality in the central Laramie Range, high-quality, transparent, sapphire-blue cordierite (iolite) was discovered in association with corundum and kyanite. The Wyoming corundum includes white, pink, red, purple-red, and blue specimens that are transparent, translucent, or opaque.

Wyoming is internationally known for its jade deposits. Jade at one time was found in great abundance, and the variety of jade known as nephrite became synonymous with the state. Nephrite is often referred to as Wyoming Jade, which has been designated the state gemstone.

Nephrite jade, produced by metasomatic alteration of amphibolite during regional metamorphism, is accompanied by a distinct wallrock alteration assemblage of bleached leucocratic granite-gneiss that is mottled pink and white by secondary clinozoisite, pink zoisite, pistacio-green epidote, green chlorite, and white sericite. Some specimens of apple-green jade collected in the past have been priceless.

Wyoming has also produced a variety of very attractive jaspers and agates. Petrified forests were once common in some of the state's basins; rock collectors have carried out enormous petrified trees several feet in diameter

and several feet high. There are many other minerals and rocks of interest in Wyoming; just a few of these are spodumene, aquamarine, gold, komatiite, serpentinite, and leopard rock.

RECOMMENDED PUBLICATIONS

There are many other publications that can provide details and assist in the understanding of the various mineral and rock localities described in this publication. Some general overview publications available from the Wyoming State Geological Survey that we recommend include:

Minerals and rocks of Wyoming, Wyoming State Geological Survey Bulletin 66, 117 p.

Traveler's guide to the geology of Wyoming, Wyoming State Geological Survey Bulletin 67, 130 p.

The geology of Wyoming's precious metal lode and placer deposits, Wyoming State Geological Survey Bulletin 68, 287 p.

Copper, lead, zinc, molybdenum and associated metal deposits of Wyoming, Wyoming State Geological Survey Bulletin 70, 229 p.

Geologic map of Wyoming, U.S. Geological Survey (1:500,000 scale).

Diamonds and mantle source rocks in the Wyoming craton with a discussion of other U.S. occurrences, Wyoming State Geological Survey Report of Investigations 53, 93 p.

Chapter 1. Introduction

Many people consider Wyoming a wide-open frontier, where new mineral discoveries are made every year, where mineral collectors and rock hounds can still find a wide variety of minerals and rocks to spice up their personal collections, and where curators can still build museum collections. Some very attractive specimens of jade, ruby, diamond, spodumene, aquamarine, gold, agate, petrified wood, and a variety of fossils collected in Wyoming have not only ended up in private collections, but have also found their way into various museums around the country.

New mineral discoveries are reported in Wyoming nearly every year. In 1998, a 7.5-ounce gold nugget was found in the South Pass area by a weekend coin hunter (Toussaint, 1998), gem-quality peridot was discovered in the Leucite Hills of the Green River Basin (Hausel, 1998a), and gem-quality cordierite was found in the Palmer Canyon area of the Laramie Mountains (Hausel, 1998b). Just a few decades ago, diamonds were accidentally discovered in southeastern Wyoming about 25 miles south of Laramie (McCallum and Mabarak, 1976). Since then more than 130,000 diamonds have been found in what is now known as the Colorado-Wyoming State Line district. The diamonds include microdiamonds to gems as large as the 28.3-carat diamond from Colorado. The largest diamond found in Wyoming to date weighed 6.2 carats (Hausel, 1998d). Many of the diamonds are of very high quality.

HOW TO USE THIS PUBLICATION

This publication was written primarily as a treatise on gemstone and related mineral and rock occurrences in Wyoming. Besides the mineralogist and gemologist, this publication was also written for the mineral collector and rock hound who enjoys hunting for rock and mineral specimens and has some background in mineralogy and geology. It was designed for and can best be used in conjunction with the various maps shown or referenced in the text. The reader is responsible for obtaining permission (when necessary) to access the various sites mentioned in this publication.

The reader may want to first plot the mineral localities they plan to visit on the recommended maps. This will help plan access routes to the areas, and help determine other possible collecting sites nearby. Some of the maps described in this publication are available at local or regional U.S. Bureau of Land Management (BLM) and U.S. Forest Service offices, as well as at the U.S. Geological Survey map distribution center in Denver. Most of the topographic, ownership, and geologic maps referred to are available either over-the-counter at the Wyoming State Geological Survey (WSGS) building on the University of Wyoming campus in Laramie or can be ordered. Other publications that may be useful are listed in the **REFERENCES CITED** section near the back of this publication; some can be purchased from the WSGS and most can be consulted at a geologic library.

There are too many interesting mineral and rock localities in Wyoming to describe in this single publication. As a result, the authors have selected several of the better localities for each rock or mineral. More detailed information on specific localities can be obtained from various publications listed in the **REFERENCES CITED** section. In addition to the alphabetical listing of rocks and minerals in the body of this publication, an **INDEX** to localities and place names is provided.

ACCESS TO LOCALITIES

It is beyond the scope of this publication to provide detailed information on land and mineral ownership or access routes to localities and mineral deposits. Because of the difficulty in researching and due to the ever-changing status of land and mineral estate ownership, access to sites and localities mentioned here is left up to the reader. Since some sites may require access routes across private land, or the sites themselves may even be on private land, you will need to obtain permission to gain access. Many other sites are located on federal and state land and generally do not require permission. However, active mining claims may have been staked on the federal land, or state leases may have been acquired by various individuals or companies. In these cases, the mineral collector should obtain permission from those individuals or companies to collect on claims and leases. Information on mining claims is available from the respective county clerk offices and from the BLM state office in Cheyenne. Information on state leases can be obtained from the Wyoming Department of Lands and Investments in Cheyenne.

There may also be some safety problems associated with some of the localities listed in this publication, such as steep slopes and unstable highwalls, underground mine workings, etc. You must use common sense when collecting in these places as well as anywhere else in Wyoming. Be aware of proper safety practices and the possible dangers of working outdoors in relatively remote areas. Remember, you are personally responsible for your own actions.

MAPS

A variety of maps are available to the public. To assist in visiting localities and collecting samples, we recommend acquiring 1:100,000-scale (1 inch equals 1.6 miles) topographic maps of the areas you intend to visit. These maps, published by the U.S. Geological Survey, contain roads, trails, towns, rivers, and topography (in metric units). In instances where greater detail is needed, you should get 1:24,000-scale (1 inch equals 2000 feet) topographic maps. In most cases, the 1:100,000-scale maps should be sufficient. The BLM also publishes general 1:100,000-scale surface and mineral management status maps that give general information on private verses state and federal land and mineral ownership. Detailed plat maps of each township are also available.

Another type of map that is very useful is a geologic map. Geologic maps can aid the collector in finding various known, unreported, or new mineral and rock occurrences. By examining geologic maps, favorable rock types can be identified for prospecting. For instance, if aquamarine is found in granite pegmatite in a certain area, then the collector may want to look at a geologic map to find similar granite pegmatites in that particular region that might contain aquamarine. In addition, agates and jaspers are localized in certain geologic formations, such as the Madison Limestone. By examining a geologic map, a collector can then search all known outcrops of this formation in their area. Geologic maps are typically available at many university libraries, the U.S. Geological Survey in Denver, and the WSGS in Laramie.

ACKNOWLEDGMENTS

Many individuals provided photos, samples, and other information to the authors, to which we are grateful. All photographs for which no specific credits are given are by the senior author (Hausel). We would like to thank Lance Cook, David Freeman, Eric Hausel, Richard Kucera, Norma Beers, Carolyn Jones, Don Eastman, Hank Hudspeth, J. David Love, and Robert Odell for the use of their photographs.

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We dedicate this bulletin to Professor Max P. Erickson, Dr. Daniel N. Miller, Jr., Dr. William P. Nash, Judy Sutherland, and Dr. J. David Love. Professor Erickson and Dr. Nash had tremendous influence on the senior author (Hausel) while he was a student at the University of Utah; this led to his interest in rocks and minerals. Without their dedication to teaching, Hausel's current level of interest in mineralogy may never have been reached. Dr. Miller, former Wyoming State Geologist, provided Hausel with the opportunity to search for gems and mineral deposits in Wyoming, and provided support for his work for which he is greatly indebted. Wayne Sutherland would like to dedicate his research to his wife Judy, whose sense of awe and beauty in rocks has been a constant inspiration to him.

As a final note, we would like to make a special acknowledgement to Wyoming's renaissance man of geology, Dr. J. David Love, whom we both admire and respect. Dave has elevated the knowledge and understanding of Wyoming's geology and mineral resources to unprecedented levels through research and pragmatic field studies, and has influenced and guided subsequent generations of geologists, including us.

Chapter 2. Gems, Minerals, and Rocks

Dietrich and Skinner (1979) defined a mineral as *any naturally occurring chemical substance having a definite chemical composition and a characteristic crystal structure*. Most minerals are inorganic. According to Dietrich and Skinner (1979), however, a few natural organic substances also fulfill these requirements. In some instances, synthetic "minerals" may also appear to fulfill these requirements with the exception that they are not naturally occurring. In such instances, these are referred to as synthetic minerals.

Rocks are composed of minerals. Dietrich and Skinner (1979) simply defined a rock as any naturally formed solid material composed of one or more minerals, and/or mineraloids, that has some degree of chemical and mineralogical constancy.

Certain minerals, because of their quality and potential value, are called *gemstones*. The term gemstone, according to Hurlbut and Switzer (1979), is applied to minerals that are *sufficiently attractive to be used for personal adornment after they are cut and polished*. The modifiers, *precious* and *semi-precious*, have been used to distinguish the more valuable from the less valuable. These terms are considered synonymous with the terms *gem* and *near-gem*, which are dependent on the economics of market conditions. For instance, near-gems can be considered as low-quality gemstones in a favorable market. In less favorable markets, the same stone may have no value as a gemstone.

Unlike gems, near-gems typically have flaws such as poor or unattractive color, mineral inclusions, or some other feature that makes them less attractive than gems. The monetary differences in value between gems and near-gems can be dramatic. For example, industrial diamonds (which have no use as a gemstone) typically sell for as little as a few dollars (or less) per carat. Uncut near-gems may be valued at 10 times that of industrial diamonds; uncut gem-quality diamonds may yield market values 100 times that of industrial diamonds. The value of a cut gemstone will often increase as much as 10 to 100 times that of the uncut mineral.

Lapidary is the art of cutting and polishing rocks and minerals. As used in this publication, the term *lapidary materials* refers to those rocks and minerals which have comparatively lower value than gemstones, are not facet-grade, and may be prepared by using simple cuts and/or polishing techniques that result in decorative or ornamental minerals or rocks. Some extraordinarily attractive *cabochons* [an unfaceted, cut material of domed or convex form, usually polished on top and unpolished elsewhere (Bates and Jackson, 1987)] have been cut and mounted in rings, pendants, and other forms of jewelry from lapidary-grade materials; some beautiful bookends, paperweights, etc., have also been produced from lapidary materials collected from Wyoming.

A variety of rocks and minerals have unique qualities that make them attractive to some collectors. Such qualities may be nebulous and difficult to define, and most often are the result of the rock or mineral being rare. For instance, an extremely rare rock known as lamproite is generally not very attractive, as it looks like common variety lava rock. However, lamproite, a mafic ultrapotassic igneous rock, is one of the rarest rock types on earth, and has value as museum and research specimens. In fact, one variety of lamproite found in Wyoming (*wyomingite*) is so rare, it was unknown elsewhere in the world until recently.

Other rocks, such as serpentinite, typically occur in attractive shades of green and are often mistaken for jade. Wyoming has many other unique rocks and minerals including nephrite jade, kimberlite, komatiite, orbicular granodiorite, etc., that are sought after by many museums, research geologists, and collectors from around the world.

Chapter 3. Geology of Selected Areas in Wyoming

A serious mineral collector needs to become familiar with the geology of Wyoming as well as the principles and terminology of geology. The state's geology is quite varied, but it is not the authors' intention to discuss the geology in detail. However, for background and convenience, the geology of some of the more interesting collecting regions in the state (as used to discuss localities in this book) is briefly described below.

We highly recommend that the collector obtain a copy of Blackstone (1988) and Love and Christiansen (1985). These will provide the collector with the basic information needed about the general geology in areas of interest. For the reader's convenience, a color, page-sized rendition of the *Geologic Map of Wyoming* is supplied as **Figure 1**. The major structural features (basins and uplifts) of the state are shown in **Figure 2**. A number of articles published in Wyoming State Geological Survey Memoir 5 (Snoke, Steidtmann, and Roberts, 1993) contain excellent summaries of different aspects of Wyoming geology. Many of these articles reflect state-of-the-art knowledge and research for the topics and contain excellent, relatively up-to-date reference lists. Other publications dealing with Wyoming geology are available from the WSGS. Knowing the geology of an area, as well as knowing what types of rocks host certain minerals, may help collectors find new mineral and rock localities in Wyoming.

ABSAROKA RANGE

The Absaroka Range of northwestern Wyoming is a high, rugged, deeply dissected plateau, much of which is above timberline, formed of stratified volcanic rocks and associated flows and flow breccias from several volcanic centers. The volcanics extend over a surface area of more than 8000 mi^2 and consist of flows, flow breccias, breccias, and reworked sedimentary facies, which form part of the Absaroka Volcanic Supergroup of middle and late Eocene age.

The Absaroka Supergroup averages more than 5000 feet thick and is divided into three groups (from oldest to youngest): Washburn, Sunlight, and Thorofare Creek. The Washburn Group is restricted to the northern part of the range and represents the oldest volcanic rocks of the Absarokas. Rocks of the Washburn Group are unconformably overlain in most places by rocks of the Sunlight and Thorofare Creek Groups. Rocks of the Thorofare Creek Group overlie the Sunlight Group.

Two formations of interest within the Supergroup include the Wiggins Formation (of the Thorofare Creek Group), a light-gray volcanic conglomerate and white tuff with clasts of igneous rocks, and the Wapiti Formation (of the Sunlight Group), which is dominantly andesitic. These two formations contain scattered fragments of petrified wood and agate. In addition to these formations, some of the volcanic centers are known to host a variety of ore minerals associated with altered volcanic rocks and veins. In particular, good ore specimens have been found in the Kirwin, Sunlight, and Stinkingwater districts (**Figure 3**).

BIGHORN MOUNTAINS

The Bighorn Mountains form an elongate north-south trending uplift in north-central Wyoming. The uplift is cored by Precambrian granite and gneiss that are unconformably overlain by Paleozoic sedimentary rocks that crop out along its flanks. The strata on the western flank have relatively gentle, low-angle (locally steep) dips into the Bighorn Basin as compared to the strata on the eastern flank which are overturned in places and dip steeply into the Powder River Basin. Precambrian rocks are exposed throughout much of the uplift. The highest peaks in the range are located west of Buffalo, where several peaks rise above 10,000 feet, culminating at Cloud Peak (13,175 feet above sea level).

At the southernmost tip of the range, northeast of Lysite, Precambrian mica schists crop out over a fairly large region. Farther north, the Precambrian core is buried by Cambrian sedimentary rocks of the Flathead and Gros Ventre Formations. Still farther north, approximately due east of Tensleep, the Precambrian core is exposed over a large area totaling more than 1000 mi^2. Near the Wyoming-Montana border, the Precambrian core is once again covered by younger Paleozoic sedimentary rocks.

The Precambrian rocks of the Bighorns have been separated into a northern granitic and a southern gneissic terrane (Osterwald, 1959). The northern granitic terrane is largely composed of pink to gray, medium- to coarse-grained plutonic rocks of granitic to quartz dioritic composition. The gneissic southern terrane is composed of gray quartzofeldspathic gneiss with minor tonalite and numerous concordant and disconcordant pods and lenses of amphibolite.

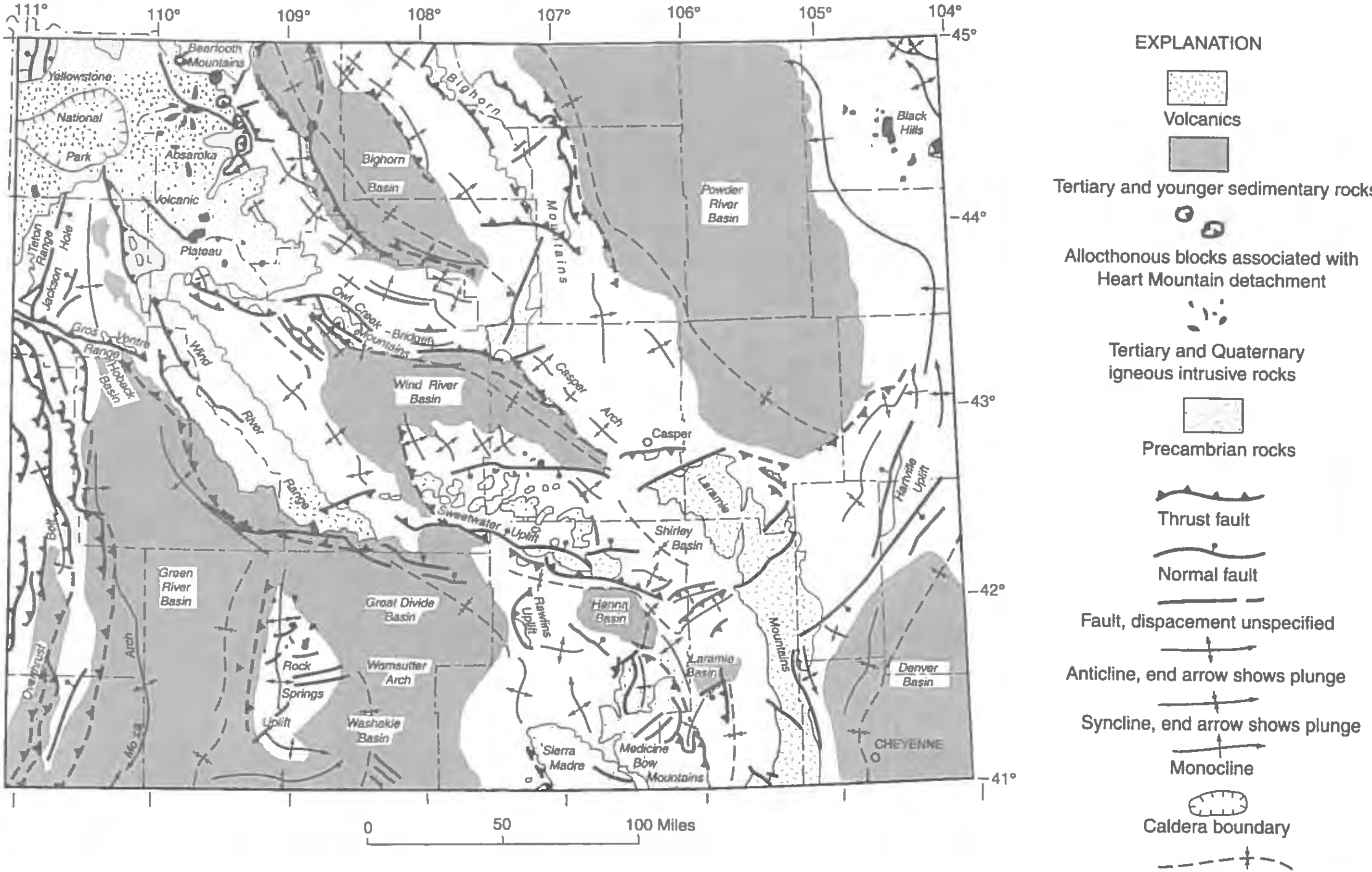


Figure 2. Major structural elements in Wyoming (from Blackstone, 1988).

BLACK HILLS

The Black Hills form a dome-shaped uplift cored by a 2.6-billion-year-old Precambrian basement complex surrounded by Paleozoic and Mesozoic limestone, shale, and sandstone. Tertiary alkalic and peralkalic igneous rocks (30 to 55 million years old) intrude older rock units at a number of locations.

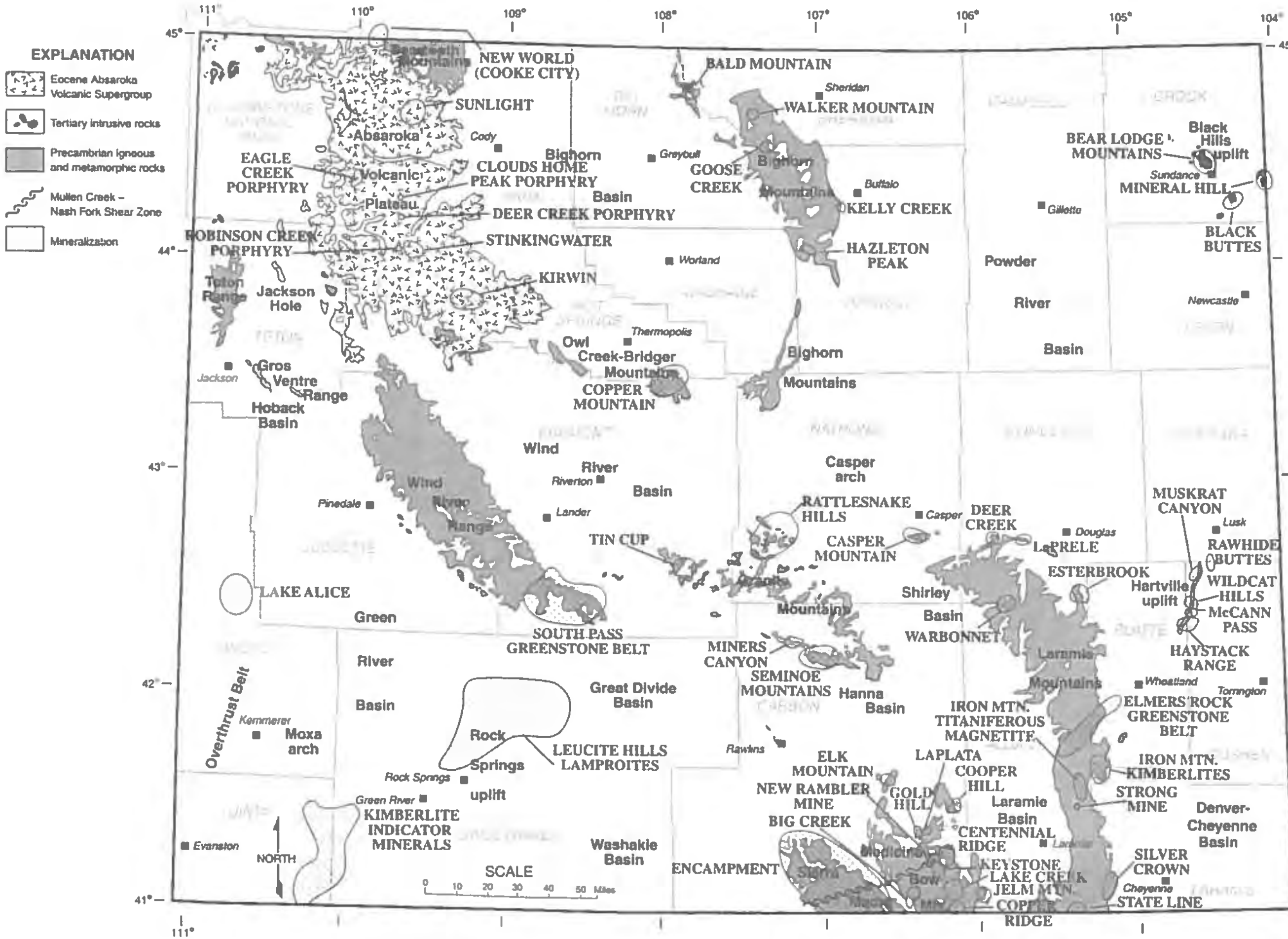
The unique geological environment and mineral and rock occurrences make the Black Hills a favorite locality for many collectors. A variety of rocks and minerals are found in this region including phonolite, fluorite, hemimorphite, galena, gold, chalcopyrite, sphalerite, wulfenite, and jasperoid. The principal mineralized areas are located in the Bear Lodge Mountains, Black Buttes, and Mineral Hill districts.

GRANITE MOUNTAINS

The Granite Mountains are an extensive range of low-lying, rounded, granite-cored hills with interspersed metamorphic rocks in central Wyoming. The Granite Mountains have been deeply eroded and consist of metamorphosed [3.2 Ga (Giga-annum or billion years old)] gneiss, schist, and amphibolite that has been extensively intruded by 2.6 Ga granite, and by later basaltic dikes. These ancient rocks are partially covered and onlapped by Tertiary sedimentary rocks including the Split Rock Formation (Miocene?) and the White River Formation (Oligocene).

Two areas in particular contain outcrops of metamorphic rocks. These are the Tin Cup district and the Rattlesnake Hills-Barlow Gap area. The Tin Cup district exhibits evidence of extensive alteration of high-temperature metamorphic fluids that produced numerous jade deposits. The district also contains a variety of other minerals including jasper, ruby, and sapphire.

The Rattlesnake Hills north of the Tin Cup district contain Tertiary [40 to 44 Ma (Mega-annum or million years old)] alkalic phonolites, latites, and related volcanic rocks which cut the older Precambrian rocks (Pekarek, 1977). The Rattlesnake Hills-Barlow Gap area is best known for low-grade, large-tonnage gold deposits, but also contains some jasper, agate, and other minerals of interest (Hausel, 1996e).


EXPLANATION
Eocene Absaroka Volcanic Supergroup
Tertiary intrusive rocks
Precambrian igneous and metamorphic rocks
Mullen Creek – Nash Fork Shear Zone
Mineralization
111°
110°
109°
108°
107°
106°
105°
104°
45°
44°
43°
42°
41°
NEW WORLD (COOKE CITY)
BALD MOUNTAIN
Sheridan
WALKER MOUNTAIN
SUNLIGHT
Absaroka
Cody
Bighorn
Greybull
GOOSE CREEK
Bighorn
Mountains
Buffalo
KELLY CREEK
EAGLE CREEK PORPHYRY
Volcanic
CLOUDS HOME PEAK PORPHYRY
Basin
Plateau
DEER CREEK PORPHYRY
ROBINSON CREEK PORPHYRY
STINKINGWATER
HAZLETON PEAK
Gillette
BEAR LODGE MOUNTAINS
Black Hills uplift
Sundance
MINERAL HILL
BLACK BUTTES
Worland
Powder
River
Basin
Newcastle
Teton Range
Jackson Hole
KIRWIN
Thermopolis
Owl Creek-Bridger Mountains
COPPER MOUNTAIN
Bighorn
Mountains
Jackson
Gros Ventre Range
Hoback Basin
Wind
River
Riverton
Basin
Casper arch
Wind River Range
Pinedale
Lander
RATTLESNAKE HILLS
Casper
DEER CREEK
Douglas
MUSKRAT CANYON
Lusk
RAWHIDE BUTTES
TIN CUP
CASPER MOUNTAIN
LaPRELE
ESTERBROOK
Hartville uplift
WILDCAT HILLS
McCANN PASS
LAKE ALICE
Green
Granite
Mountains
Shirley
Basin
WARBONNET
SOUTH PASS GREENSTONE BELT
MINERS CANYON
HAYSTACK RANGE
Laramie
River
SEMINOE MOUNTAINS
Hanna Basin
Mountains
Wheatland
Torrington
Overthrust Belt
Basin
Great Divide Basin
IRON MTN. TITANIFEROUS MAGNETITE
ELMERS ROCK GREENSTONE BELT
Kemmerer
Moxa arch
Rock Springs uplift
LEUCITE HILLS LAMPROITES
Rawlins
ELK MOUNTAIN
LAPLATA
COOPER HILL
IRON MTN. KIMBERLITES
Rock Springs
NEW RAMBLER MINE
GOLD HILL
Laramie Basin
STRONG MINE
Denver-Cheyenne Basin
Green River
KIMBERLITE INDICATOR MINERALS
BIG CREEK
CENTENNIAL RIDGE
Evanston
NORTH
Washakie Basin
Medicine Bow Mtns
Laramie
SILVER CROWN
SCALE
0 10 20 30 40 50 Miles
ENCAMPMENT
Sierra Madre
KEYSTONE
LAKE CREEK
JELM MTN.
COPPER RIDGE
Cheyenne
STATE LINE

The Greater Green River Basin of southwestern Wyoming includes the Great Divide or Red Desert, Washakie, and Green River basins, the smaller subbasins (Hoback and Bridger basins), and structural features that separate the basins. One of the more prominent of these is the Rock Springs uplift, which separates the Green River Basin from the Washakie and Great Divide basins. The Greater Green River Basin region is known for a variety of petrified wood, agates, garnets, and other minerals.

The source for some of the petrified wood and agate appears to be the Laney Shale Member of the Green River Formation and the overlying Bridger Formation, both of Eocene age. The Laney Shale Member was deposited in a large inland lake system during the early Eocene (40 to 50 million years ago). The lake, known as Lake Gosiute, filled much of the Green River Basin and was the center for the deposition of extensive lacustrine (lake) deposits. At its greatest extent, this prehistoric lake system covered almost 15,000 mi^2 in much of southwestern Wyoming, northwestern Colorado, and northeastern Utah (Bradley, 1964).

During deposition of Laney Shale sediments, the climate was warm and moist. Under such conditions, a widespread, heavily forested swampland flourished in this part of Wyoming. Lake Gosiute expanded and contracted in response to periods of increased precipitation followed by drier periods. The fluctuation allowed for expansion of the forests around the lake as it receded, or drowned the timber as the lake rose. The drowned timber was gradually buried in lake sediments and showers of volcanic ash. Over time, some of the wood became petrified by the silica leached from the volcanic material.

The overlying Bridger Formation is primarily fluviatile (fresh water, stream deposited) with some thin lacustrine layers. Locally the formation contains silicified limestones and marlstones. Petrified wood is common in the Bridger Formation, particularly in the vicinity of Oregon Buttes (Bradley, 1964). Much of the wood is encrusted with algae and was silicified by processes similar to those that petrified materials in the underlying Laney Shale. In addition to the wood, some clear chalcedony and vein moss agates are found in this region.

GREEN MOUNTAIN

Green Mountain is located in central Wyoming directly south of the Granite Mountains and between the Ferris Mountains to the east and Crooks Mountain to the west. The Green Mountain area is accessible from Jeffrey City by roads leading south of U.S. Highway 287/789. The Green Mountain area encloses the Green Mountain-Crooks Gap uranium mining district, which is underlain by Archean granitic and gneissic rocks onlapped by Paleozoic, Mesozoic, and Tertiary sedimentary rocks. Much of Green Mountain is covered by the Crooks Gap Conglomerate, which consists of giant granite boulders in an arkosic matrix (Love and Christiansen, 1985). The age of the conglomerate may be Oligocene(?). Several sedimentary rock formations in this area have yielded considerable detrital jade.

HARTVILLE UPLIFT

The Hartville uplift is composed of a series of relatively low, northeast-trending hills between Wheatland and Lusk and consists of Precambrian-age eugeoclinal metasedimentary and metavolcanic rocks which are unconformably overlain by Paleozoic limestones, sandstones, and dolomites of the Hartville and Guernsey formations (Snyder and others, 1989). The region is known for its hematite, copper, and agates.

LARAMIE MOUNTAINS

The Laramie Mountains form an elongate north-south anticlinal uplift cored by Precambrian rocks and flanked by upwarped Phanerozoic sedimentary rocks. Along the western flank of the range, the Phanerozoic rocks unconformably overlie the Precambrian basement and dip at low angles into the Laramie and Shirley Basins. On the eastern flank, pre-Tertiary sedimentary rocks generally dip steeply into the northern Denver-Julesburg Basin (locally known to some as the Cheyenne Basin or Cheyenne-Denver Basin), and in places are overturned and locally overthrust by Precambrian crystalline rocks. Relatively flat-lying Tertiary rocks overlie the pre-Tertiary rocks (including the Precambrian basement in some areas) and obscure the structure along the eastern flank of the mountains. Within the Precambrian core of the range, several mining districts and mineralized areas are recognized, including the Deer Creek, Esterbrook, Iron Mountain, Silver Crown, State Line, and Warbonnet districts; Elmers Rock greenstone belt; and the Casper Mountain, Garrett (Sellers Mountain), and LaPrele areas.

The Precambrian rocks of the Laramie Mountains are divisible into a southern Proterozoic province (Green Mountain terrane) and a northern Archean terrane (Wyoming Province). These two terranes meet near the center of the Laramie Mountains where a 350 mi^2, 1.5 Ga anorthosite batholith intrudes the projected trend of the Mullen Creek-Nash Fork shear zone (referred to as the Cheyenne belt) from the Medicine Bow Mountains to the west.

The Green Mountain terrane consists of 1.8 Ga mafic to intermediate metavolcanic and associated metasedimentary rocks (Peterman and others, 1968). These were intruded by 1.4 Ga granite, which includes the Sherman Granite and related felsic phases (Peterman and others, 1968).

Rocks in the central and northern Laramie Mountains are part of the Wyoming Province and include 3.0 Ga gneiss, migmatite, granite, and supracrustal successions of metasedimentary and metavolcanic rock (Johnson and Hills, 1976). These have been intruded by Archean granites.

The Precambrian rocks of the Laramie Mountains are unconformably overlain by Phanerozoic sedimentary rocks on the flanks of the range. Limestones of the Pennsylvanian and Permian Casper Formation, in particular, are noted as a source for jasper and agate.

MEDICINE BOW MOUNTAINS

The core of the Medicine Bow Mountains consists of two distinct terranes: to the north, the core consists of an older quartzofeldspathic gneiss unconformably overlain by metasedimentary rocks; to the south, the core consists of relatively younger metavolcanic and metasedimentary rocks. These contrasting rock successions are separated by a major east-west trending crustal suture that divides the Precambrian rocks of Medicine Bow Mountains. The suture, known locally as the Mullen Creek-Nash Fork shear zone, is part of the larger and more extensive Cheyenne belt that continues east through the Laramie Mountains and west through the Sierra Madre. The Medicine Bow Mountains contain a variety of rocks and minerals; most notable are placer gold and associated nuggets, and platinum and palladium mineralization.

OWL CREEK MOUNTAINS

The Owl Creek Mountains form a relatively narrow, linear, east-west trending asymmetrical anticlinal uplift cored by Precambrian basement rocks in north central Wyoming. The northern flank of the range is unconformably overlain by Paleozoic sedimentary rocks that dip to the north into the Bighorn Basin. The southern flank is onlapped by Tertiary strata which may conceal Paleozoic and Mesozoic rocks that are overthrust by Precambrian rocks.

The Precambrian core of the Owl Creek Mountains has been subdivided into three different rock groups based on age. The oldest rocks are supracrustal metamorphics exposed within the Copper Mountain district. The metamorphic rocks have been intruded by granites and mafic dikes which comprise the other two rock groups.

Within the Owl Creek Mountains is the Copper Mountain district. The district lies southeast of Thermopolis, northeast of Shoshoni, and east of Wind River Canyon. This area has also been called the Bridger Mountains. Three units of metamorphic rocks occur in the district: the southernmost unit consists of amphibolite, quartzofeldspathic gneiss, and mica schist; the central unit consists of banded iron formation, metapelite, quartzite, and amphibolite; and the northern unit is dominated by amphibolite with subordinate quartzofeldspathic gneiss (Hausel and others, 1985). Some mineral occurrences of interest to collectors include copper, beryl, agate, jasper, tourmaline, and scheelite.

SEMINOE MOUNTAINS

The Seminoe Mountains north of Sinclair, Wyoming are formed of metasedimentary and metavolcanic rocks (>2.7 Ga) exposed in a broad, vertically plunging fold. These were intruded and folded by granodiorite (>2.6 Ga) (Snyder and others, 1989). The core of the range is unconformably overlain by Phanerozoic sedimentary rocks that form a spectacular, steeply dipping precipice along the southern flank of the range.

The metamorphic rocks in the Seminoe Mountains have been subdivided into three mappable units. The lower unit consists of mafic metavolcanic and volcaniclastic rocks named the Sunday Morning Creek Metavolcanics. This unit is overlain by mafic and ultramafic schists, named the Bradley Peak Ultramafics, that form the middle unit. Rocks of the middle unit consist of massive to highly foliated amphibolites, serpentinites, and tremolite-talc-chlorite schists. The Bradley Peak Ultramafics are overlain by interlayered metasedimentary and metavolcanic rocks of the upper unit, named the Seminoe Formation, which includes quartz-magnetite-grunerite iron formation, chlorite schist, metagreywacke, metapelite, metabasalt, metatuff, and felsic schist. Notable minerals and rocks in the Seminoe Mountains include gold, copper, serpentinite, metakomatiite, jasperized iron formation, grunerite, and spectacular folded metamorphic rocks.

SHIRLEY MOUNTAINS

The Shirley Mountains, located along the southwestern margin of the Shirley Basin north of the town of Medicine Bow, are a Precambrian-cored uplift dominated by a core of granitic rocks with occasional mafic dikes. The margins of the uplift are unconformably overlain by steeply dipping Phanerozoic rocks.

SIERRA MADRE

The Sierra Madre lie due west of the Medicine Bow Mountains across the synclinal Saratoga Valley (also referred to as the Platte River valley). The geology of the Sierra Madre is similar to that of the Medicine Bow Mountains, and both ranges were uplifted during Laramide time. As in the Medicine Bow Mountains, the Precambrian core of the Sierra Madre consists of rocks from two provinces separated by a major east-west trending suture known locally as the Mullen Creek-Nash Fork shear zone. The entire Sierra Madre was once part of the historical Grand Encampment mining district, which originally included both the Sierra Madre and much of the Medicine Bow Mountains. The Grand Encampment district was subdivided into several smaller districts including the Battle, Douglas Creek, Gold Hill, La Plata, Purgatory Gulch, Sandstone, New Rambler, and several other districts in both the Sierra Madre and Medicine Bow Mountains. These districts were known for a variety of copper minerals, some gold, lead, and zinc, and produced some good specimens of garnet.

The Wind River Range in western Wyoming forms a northwest-trending asymmetrical arch. Along the northeastern flank of the range, Paleozoic and Mesozoic strata dip gently into the Wind River Basin. Along the northern and northwestern flanks, the strata are folded and faulted against the Precambrian basement complex. Major boundary faults along the southern and southwestern flanks of the range place Precambrian igneous and metamorphic rocks over younger sedimentary rocks in the Greater Green River Basin.

The Archean basement complex which forms the core of the Wind River Range is a high-grade metamorphic and igneous complex of migmatite, amphibolite- to granulite-facies felsic orthogneiss and paragneiss, intruded by quartz diorite and granite plutons.

Near the south end of the range, the 2.6 Ga Louis Lake batholith cuts the South Pass greenstone belt (Stuckless and others, 1985). The South Pass greenstone belt consists of a synform of metasedimentary, metavolcanic, and plutonic rocks (Hausel, 1991a). The South Pass greenstone belt has been subdivided into the Anderson Ridge area, the Lewiston district, and the South Pass-Atlantic City district. These areas are primarily known for gold.

Chapter 4. Mineral and Rock Localities in Wyoming

Wyoming contains a wide variety of rocks and minerals, and some of the best rock exposures in the United States are found in Wyoming. Because there are far too many localities of interest in Wyoming to describe here, we have selected some of the better localities. More information on various localities can be obtained from publications listed in the **REFERENCES CITED** section at the back of this book.

This chapter is arranged alphabetically by rock or mineral name. After a general description of the rock or mineral, its occurrences in Wyoming are detailed, first by region (again, alphabetically) and then by area or subregion (when necessary). Prospects or occurrences in a particular region or subregion are indicated by side headings in bold face and italics. Prospects and occurrences discussed in the text that are unnamed or for which the name is not known are indicated by a legal description, also in bold face and italics. An **INDEX** to prospect names and occurrences is provided in the back of this book.

AGATE (see QUARTZ)

ALABASTER (also see SELENITE)

Alabaster [$(CaSO_4) \cdot 2H_2O$], a massive, crystalline, marble-like form of gypsum, is extremely soft and easily cut and carved. It has a hardness of only 2 on Mohs hardness scale (Mohs scale increases in hardness from 1 to 10). For information on mineral hardness, see Hausel (1986b). Alabaster is so soft it can be scratched by a fingernail. Because of its softness, it is not considered a gemstone or semi-precious stone. But alabaster has the unique quality of being carvable without great difficulty, and is sometimes sought by specialized collectors. Alabaster typically occurs as opaque white masses, but may vary in color from white to red to yellow-orange. The transparent form of alabaster is known as selenite (see **SELENITE**), and is commonly found along the margins of some basins in Wyoming. An attractive form of selenite known as *satin spar* (see **SELENITE**) has also been found in Wyoming.

Alabaster is often found in gypsum-bearing formations that crop out along the flanks of many of the major uplifts in the state. Typically, it is associated with the Permo-Pennsylvanian Goose Egg Formation, the Triassic Chugwater (Spearfish) Formation, and the Jurassic Gypsum Spring Formation (**Figure 1**). Additional localities could be discovered by examining the available geologic maps which show these formations, and then prospecting these favorable host rocks in the field.

Powder River Basin

Gardiner Mountain. This area is located in W/2 section 29, T45N, R83W. Small amounts of alabaster have been found 2 to 3 miles west of Mayoworth in the Goose Egg Formation along the flank of Gardiner Mountain. This area is on the extreme western margin of the Powder River Basin along the flank of the Bighorn Mountains uplift. Some alabaster specimens from this area have been used to produce bases for sculptures (Sutherland, 1990). *Recommended map: U.S. Geological Survey topographic map of the Kaycee 1:100,000-scale Quadrangle.*

Newcastle area. Osterwald and others (1966) reported that white, yellow, and red alabaster was found in the Spearfish Formation east and north of Newcastle, northeastern Wyoming. No specific details were provided.

Shirley Basin

Freezeout Hills. This locality is in sections 1 and 12, T25N, R80W. Alabaster is found in outcrops of the Goose Egg Formation in the Pine Hill area near the Freezeout Hills along the southern margin of the Shirley Basin (Osterwald and others, 1966). This area lies a short distance west of Highway 487 between Medicine Bow and Shirley Basin townsite. *Recommended map: U.S. Geological Survey topographic map of the Shirley Basin 1:100,000-scale Quadrangle.*

Wind River Basin

Little Popo Agie River. Osterwald and others (1966) reported white, yellow, and red alabaster was found in the Chugwater Formation along the Little Popo Agie River in Fremont County south of Lander.

AMBER

Amber is a fossil plant resin produced by a variety of conifer trees and possibly by some flowering plants. By definition, amber should be relatively old–at least middle Tertiary, compared to the geologically younger copal.

Amber is a soft (hardness of 2 to 2.5 on the Mohs scale), plastic-appearing material of low specific gravity (1.05 to 1.10) that is easily cut, carved, and polished. It has a conchoidal fracture with oily luster and ranges from almost colorless to yellow, brownish-yellow, or orange-yellow. Amber melts at a relatively low temperature (250° to 325°C), and is composed of about 79% carbon, 10.5% hydrogen, and 10.5% oxygen with a trace of sulfur. Its main constituent is succinic acid, $COOH(CH_2)_2COOH$ (Sinkankas, 1959).

When burned, amber gives off an aroma similar to pine. Amber was initially called electrum by early Greeks because of its ability to take on an electrical charge when rubbed with wool or similar material. Amber has limited use as a gem due to its softness, although some amber has been used for beads and other decorations. Inclusions of insects found in some amber enhance its value as a collector's item.

Rocks as old as Pennsylvanian are reported to contain some fossil resins, although amber-producing plants did not flourish until Late Cretaceous. In North America during the mid-Tertiary, the climate cooled and the great resin-producing Eocene forests disappeared, although some flowering tropical plants produced amber into the late Tertiary. Resin secretion is generally believed to be a mechanism some plants use for sealing bark wounds in trees and protecting vulnerable plant parts from insects and herbivores in warm, humid climates (Mustoe, 1985).

Cretaceous amber is found in northern and central North America whereas Eocene amber, which is relatively abundant along the Baltic coast in Europe, is rather scarce in North America. Amber younger than mid-Eocene has not been reported from North America although it is abundant in some Oligocene-Miocene sediments in Central America (Mustoe, 1985).

Because of its low specific gravity and low hardness, amber is most commonly associated with rocks from low-energy depositional environments such as coal seams or carbonaceous shales and siltstones. Carbonaceous or coaly shales appear to contain better quality amber than coal because amber in coal shows greater fracturing due to compression during the coalification process (J. David Love, personal communication to Sutherland, 1989). Amber may occur as scattered nodules in all these sedimentary rocks.

Gem-quality, early Eocene amber with a deep reddish-brown color was found by J. David Love in 1934 in the Paleocene Hanna Formation of the Hanna Basin, southeastern Wyoming (**Figure 1**). A few sizable lumps of amber have also been identified in Late Cretaceous coaly shales (Mesaverde Formation equivalent) in the Jackson Hole area (J. David Love, personal communication to Sutherland, 1989). Ed Heffern (personal communication to Sutherland, 1989) reported that small pieces of amber were recovered from the Healy coal bed at the east edge of Buffalo from core drilled by the U.S. Geological Survey in 1975. The amber reportedly was fluorescent.

Small nodules and veins of amber have been reported in Upper Cretaceous coals of the Adaville Formation and in Paleocene and Eocene coals in the Powder River Basin (Glass, 1975). Veins of amber, up to 3 inches wide and several feet long, occur in the thick Wyodak coal seam near Gillette (Gary B. Glass, personal communication to Sutherland, 1990). Thin seams of amber-like material were reported by Sinkankas (1959) and Glass (1975) from Fort Union Formation coal beds in Converse County. It is quite likely that amber, in small amounts, may be found in all of the Tertiary basins of Wyoming (**Figure 2**). Many of the coal-bearing rocks of Wyoming provide potential areas for amber (see Jones, 1990).

AMETHYST (see QUARTZ)

ANDALUSITE, KYANITE, SILLIMANITE, STAUROLITE

Andalusite, kyanite, sillimanite, and staurolite are all alumino-silicates associated with alumina-rich, mica schists known as metapelites. Cordierite (see **CORDIERITE**) is also associated with metapelites. Usually, one or more of these alumino-silicates are found in the same metamorphic terrane and can provide a general barometer of the intense pressure and temperature that the mica schist was subjected to. For example, kyanite forms at relatively high pressure and low temperature compared to sillimanite and andalusite. Andalusite as well as cordierite form at relatively higher temperatures and lower pressures than sillimanite and kyanite. Sillimanite forms at high pressures and temperatures between the other alumino-silicates.

Andalusite, kyanite, and sillimanite are polymorphs with the general chemical composition of $Al_2(SiO_5)$. *Andalusite* is orthorhombic and forms dull, rough, prismatic crystals with square cross sections in mica schists, and is often partially replaced by sericite. Most andalusite found in Wyoming is opaque and gray to brown. However, andalusite crystals of brownish-pink,

GENERALIZED GEOLOGIC MAP OF WYOMING

MAP EXPLANATION

Approximate age in millions of years before present

CENOZOIC IGNEOUS ROCKS

- Quaternary, Pliocene, and Miocene rhyolite and basalt; some intrusives
- Upper Tertiary to Cretaceous(?) intrusive rocks; some extrusives
- Eocene Absaroka Volcanic Supergroup

SEDIMENTS AND SEDIMENTARY ROCKS

Cenozoic

- Quaternary unconsolidated sediments
- 1.6 — Lower Quaternary, Pliocene, and Miocene
- 24 — Oligocene
- 38 — Middle Eocene; some Upper Eocene
- 49 — Lower Eocene
- 55 — Paleocene
- 66

Mesozoic

- Upper Cretaceous
- 96 — Upper and Lower Cretaceous
- Lower Cretaceous; some Jurassic
- 138 — Jurassic; some Lower Cretaceous
- 205 — Triassic
- 245

Paleozoic

- Permian and Pennsylvanian; some Mississippian and Triassic
- 330 — Cambrian, Ordovician, Devonian, and Mississippian
- 570

IGNEOUS AND METAMORPHIC ROCKS

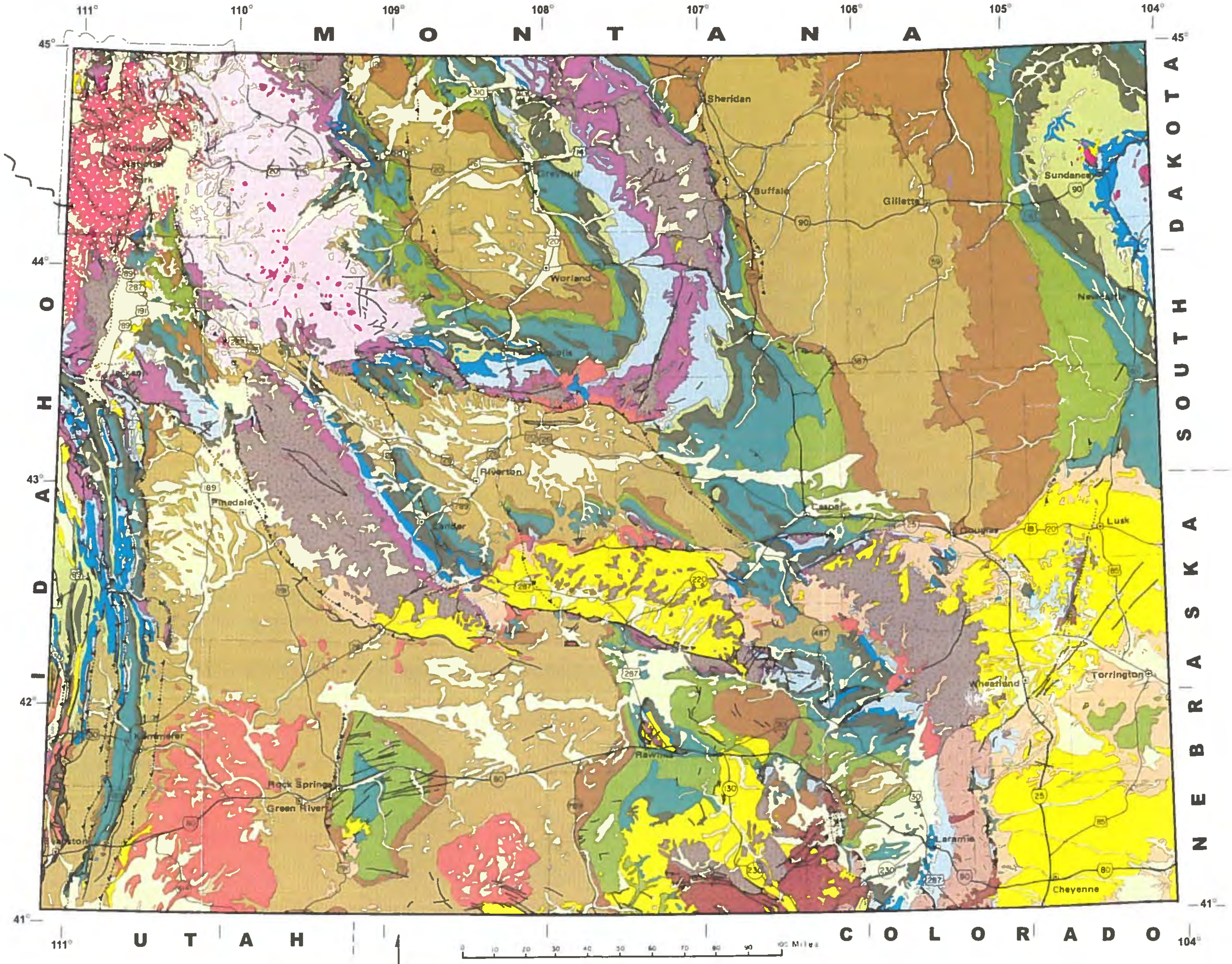
Precambrian

Major unconformity

- 1,400 — Middle Proterozoic intrusive rocks
- Early Proterozoic igneous and metamorphic rocks
- 2,500 — Archean igneous and metamorphic rocks

MAJOR FAULTS

- Fault (dotted where concealed)
- Thrust fault; teeth on upper plate (dotted where concealed)



Wyoming State Geological Survey
Thomas A. Drean, Director and State Geologist

Laramie, Wyoming
2014 Reprint

Cartography by Phyllis A. Ranz

Modified and adapted from Roberts, S., 1989, Wyoming Geomaps: Wyoming State Geological Survey Educational Series 1, 41 p.

white, rose-red, red-brown, green, yellow, and violet have been reported elsewhere. It has a hardness from 6.5 to 7.5 (Mohs scale) and specific gravity from 3.1 to 3.2. But because of the common partial replacement of andalusite by sericite, the specific gravity may be relatively low. In addition, its hardness is often difficult to determine because of partial replacement by softer mica.

Kyanite is the triclinic polymorph of $Al_2(SiO_5)$. Typically, kyanite forms distinct light-blue, bladed, opaque crystals with a specific gravity from 3.53 to 3.65. Gem varieties of kyanite are uncommon. Good crystals of kyanite have unique hardness properties which are useful in identifying this mineral. Parallel to the greatest length of the crystal (c-axis), it has a hardness of 5 and can be scratched with a pocket knife. However, in the direction of the short axis, it has a hardness of 7 and cannot be scratched with a pocket knife unless the mineral is altered or weathered. In other words, there should be a noticeable difference in the mineral's hardness depending on the direction in which it is scratched. This variation in hardness along with its distinctive blue color are useful in identifying this mineral.

Sillimanite, another orthorhombic polymorph, forms slender, prismatic, or fibrous white to colorless crystals with vitreous to silky luster. Sillimanite has a hardness from 6.5 to 7.5 and a specific gravity from 3.23 to 3.27. The mineral rarely forms transparent crystals suitable for cutting. No gem varieties of sillimanite have yet been reported in Wyoming.

Staurolite, a complex alumino-silicate $(Fe,Mg)_2(Al,Fe)_9O_6(SiO_4)_4(O,OH)_2$, is a monoclinic (psuedo-orthorhombic) mineral with a hardness from 7 to 7.5. It commonly forms distinct brown to yellow-brown, cruciform (cross-like) twins, although it may occur as flat, elongated crystals. It is typically associated with kyanite, muscovite, and almandine garnet. No gem varieties of staurolite are known in Wyoming.

These metamorphic minerals are restricted to the Precambrian cores of mountain ranges in Wyoming that contain large regions of moderate to relatively high-grade metamorphic rocks. The lithostatic pressure from a thick pile of sedimentary rocks that once buried Precambrian sedimentary terranes resulted in metasomatic alteration (metamorphism) of the rocks. In other words, the minerals in these rocks slowly changed to other minerals more suited to withstand the higher pressure and temperature of deep burial.

Many alumina-rich sedimentary rocks (such as shales) were greatly affected by the metamorphism. Under deep burial, these shales slowly changed to mica schists with a distinct schistose fabric. In addition to mica, *porphyroblasts* (large metamorphic crystals) of large aluminum-rich silicate minerals known simply as alumino-silicates grew in many of these schists. Much later in geologic history, dynamic forces in the earth uplifted large blocks of the earth along faults or upwarps, producing today's mountain ranges. Erosion during and after uplift removed much of the overlying rocks, so that today the old metamorphic crystalline cores of the mountains are now exposed. The *Geologic Map of Wyoming* (Love and Christiansen, 1985), clearly shows that the only places these ancient Precambrian rocks can be seen are in the cores of many mountain ranges. Also note that metasedimentary rocks shown on the map indicate the best places to search for alumino-silicates.

Areas where alumino-silicates have been reported in Wyoming include the Copper Mountain area of the Owl Creek Mountains (Hausel, Graff, and Albert, 1985), South Pass in the Wind River Range (Hausel, 1991a), the Seminoe Mountains (Hausel, 1994b), the Elmers Rock greenstone belt (Graff and others, 1985), and the Sierra Madre.

In some of these metasedimentary areas, you might find some attractive specimens of mica schist with abundant sky-blue kyanite crystals. Rocks known as peanut schists, which contain porphyroblasts of andalusite or cordierite, are found in the South Pass area of the Wind River Range; staurolite crosses in mica schists and some gem-quality, sapphire-blue crystals of cordierite have been found west of Wheatland.

Granite Mountains

The Granite Mountains of central Wyoming (**Figure 3**) consist of an Archean terrane of granite and gneiss with interspersed metamorphic rocks. The metamorphic rocks (particularly mica schists) are considered favorable terranes to find alumino-silicates.

Barlow Gap. In the SW SW SW section 7, T31N, R87W, massive clusters of white to very light-green sillimanite crystals with good basal cleavage are found in mica schist (**Figure 4, Plate 1**). Some crystals exceed 3.5 inches in length.

Laramie Mountains

Elmers Rock greenstone belt

Cooney Hills. Graff and others (1982) reported porphyroblastic alumino-silicates in metapelites in the greenstone belt (**Figure 3**) south of Palmer Canyon in the Cooney Hills area (T23N, R69W) north of Sybille Canyon. The alumino-silicates include kyanite, sillimanite, and andalusite. Kyanite-biotite gneiss is found along the western flank of the Cooney Hills (Graff and others, 1982). Samples contain large, light-blue, fractured, translucent kyanite blades up to 1.5 inches in length. The Cooney Hills are surrounded by private land. *Recommended map: U.S. Geological Survey topographic map of the Rock River 1:100,000-scale Quadrangle.*

Palmer Canyon region

The Palmer Canyon region west of Wheatland (Figure 5), and areas north and south of Palmer Canyon, contain metapelites with a variety of porphyroblasts. Some porphyroblasts reported in this region include kyanite, sillimanite, andalusite, staurolite, cordierite, and corundum (in the form of low-grade rubies and sapphires). *Recommended map: U.S. Geological Survey topographic map of the Laramie Peak: 1:100,00-scale Quadrangle.*

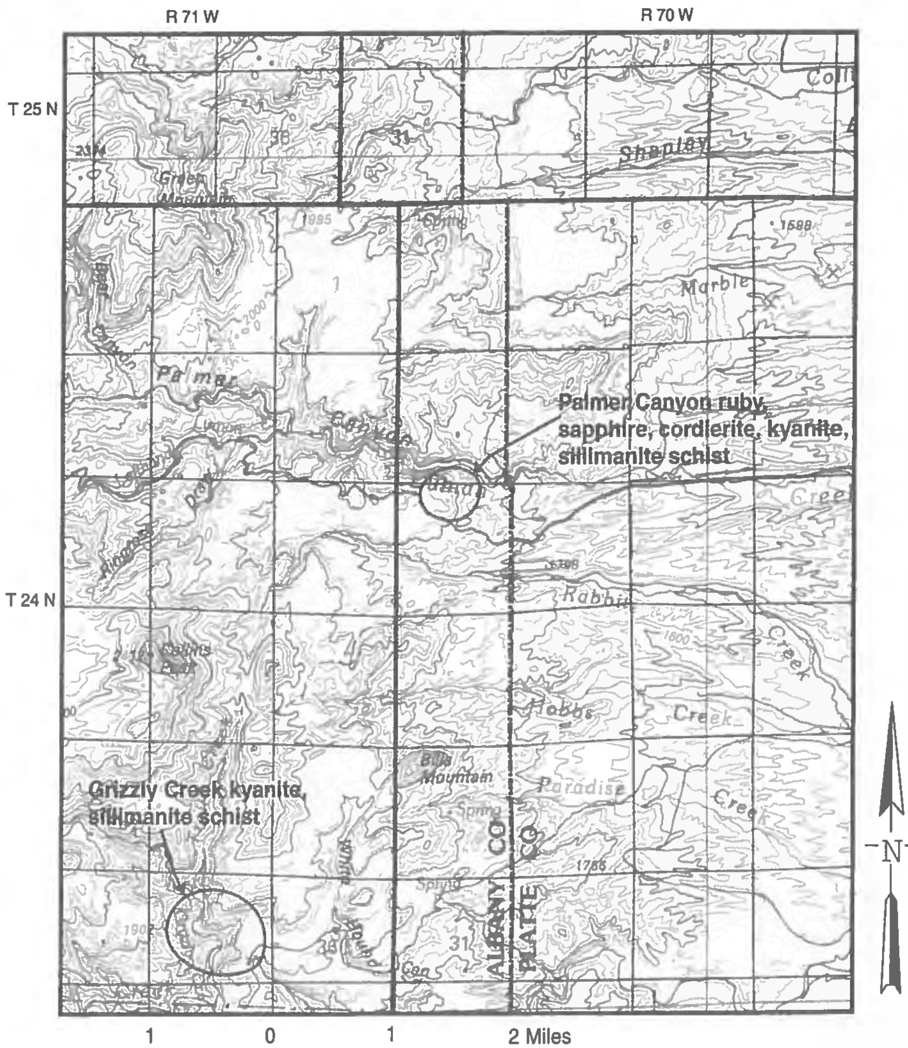


Figure 5. Location map of the Palmer Canyon-Grizzly Creek area, adapted from the U.S. Geological Survey 1:100,000-scale topographic map of the Laramie Peak Quadrangle.

Grizzly Creek prospect. Kyanite- and sillimanite-rich schists are reported in a 300- by 5000-foot zone in the Grizzly Creek area (section 35, T24N, R71W), 3 to 4 miles southwest of the Palmer Canyon prospect (Osterwald and others, 1966). The alumino-silicates coincide with a fault zone that is several miles long, as indicated by drag folds in the country rock schist and gneiss and by brecciation of some of the schists (Hagner and Spanski, undated).

Owen Creek area. This area is in sections 9 and 10, T25N, R71W. About 7 miles north of Palmer Canyon, kyanite, sillimanite, cordierite, and some relict staurolite were reported by Snyder and others (1995) in pelitic schists. Similar porphyroblasts were also reported in a few small outcrops farther north.

Palmer Canyon. Located in the N/2 section 18, T24N, R70W, this prospect (also known as the Roff vermiculite prospect) is north of the Palmer Canyon road. The prospect is about 17 miles west of Wheatland in the Laramie Mountains and is on private property [permission from the landowner is needed to visit the site]. The Palmer Canyon road originates in Wheatland, and is paved much of the distance to the prospect. At the Palmer Canyon prospect, mica schists and gneisses contain vermiculite, kyanite, sillimanite, corundum, transparent cordierite, and biotite.

This prospect lies within a gneiss complex northeast of the Elmers Rock greenstone belt, and should be of interest not only to mineral collectors, but also to metamorphic petrologists, as the pelitic gneisses and schists in this region contain a variety of porphyroblasts. For example, the Grizzly Creek prospect (described above) southwest of the Palmer Canyon deposit reportedly is underlain by schists with abundant kyanite and sillimanite, whereas the Palmer Canyon deposit not only contains kyanite and sillimanite, but also has some blue cordierite (see **CORDIERITE**), and pink and white corundum (see **CORUNDUM**) **(Figure 6, Plate 1)**.

In addition to cordierite, the Palmer Canyon prospect also contains other porphyroblasts. Near the cordierite gneiss along the eastern edge of the property are white, fibrous, sillimanite crystals in biotite schist. A short distance west of the sillimanite schist, near an old Roff prospect pit, the schist contains chlorite with large prisms of pale- to dark-blue kyanite. Some brown staurolite is also found in the schist. *Recommended map: U.S. Geological Survey topographic map of the Reese Mountain 1:24,000-scale Quadrangle.*

Owl Creek Mountains

Copper Mountain district. This area in the Owl Creek Mountains (**Figure 3**) has a variety of interesting minerals and rocks, including some alumino-silicates, banded iron formation, copper minerals, gold, scheelite, beryl, and other minerals and rocks. Pelitic schists with nodular porphyroblasts are relatively common in some outcrops in the district. The porphyroblasts are formed of opaque to translucent, poor quality cordierite, andalusite, sillimanite, and cummingtonite, along with some garnet. *Recommended map: Geologic map of the Copper Mountain district (in pocket) in Hausel, Graff, and Albert (1985).*

Sierra Madre

Osterwald and others (1966) reported that kyanite was found in schists and pegmatites in sections 19, 20, 30, and 36, T14N, R83W, and in sections 1 and 11, T13N, R83W. Some alumino-silicates have been found elsewhere in the region. *Recommended maps: U.S. Geological Survey geologic map, scale 1:50,000 (Houston and Graff, 1995), and U.S. Geological Survey topographic map of the Saratoga 1:100,000-scale Quadrangle.*

Baggot Rocks. Baggot Rocks lies between Encampment and Saratoga in section 15, T15N, R83W. The Baggot Rocks turnoff is identified by a sign posted along Highway 130, a few miles north of Encampment. From the turnoff, the area is reached by driving three miles east on the dirt road (**Figures 7** and **8**).

The property was mined for vermiculite between 1937 and 1941, and three shafts, a drift, and a number of prospect pits were dug. One shaft was sunk to a depth of 65 feet and was connected to a 95-foot-deep shaft farther up the hill by a 112-foot-long drift driven between the shafts. A third shaft on top of the hill was sunk to a depth of 105 feet.

The schist on the property contains kyanite and sillimanite in patches enclosed by the vermiculite. The vermiculite schist was also reported to contain a few specks of corundum (Hagner, 1944). Based on similar corundum occurrences reported elsewhere in Wyoming, there is a possibility for ruby or sapphire here.

East Cottonwood Creek area (Carlton group). In sections 19 and 20, T14N, R83W, granite pegmatite with blades of kyanite intrudes kyanite-biotite-quartz-plagioclase gneiss and schist (Houston and Graff, 1995). The kyanite forms as much as 68% of the schist and occurs as white to pale-blue bladed crystals.

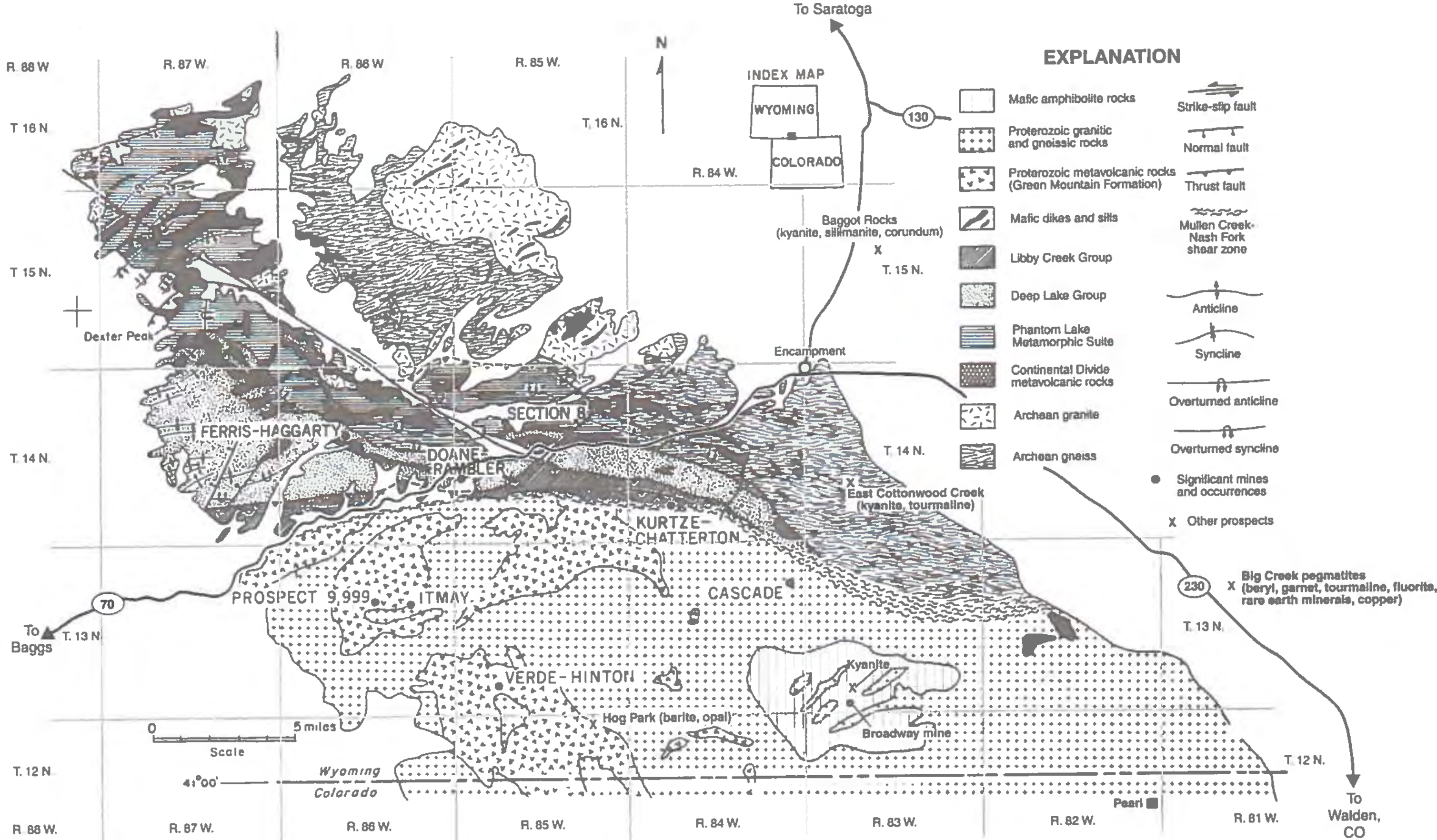


Figure 7. Generalized geologic map of Precambrian rocks showing selected mineral and rock localities in the Sierra Madre (modified and redrafted from Karlstrom and others, 1981).

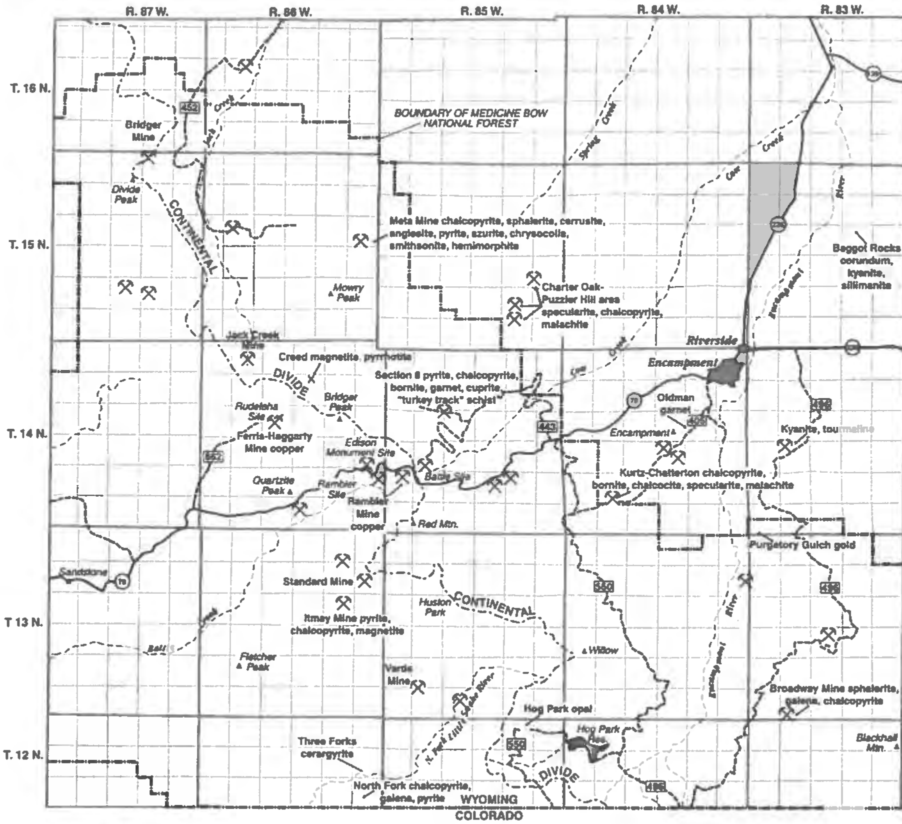


Figure 8. Generalized map of rock and mineral localities in the Sierra Madre (adapted from U.S. Forest Service, 1998, 1:126,720-scale map of Medicine Bow National Forest).

The kyanite is found in association with vermiculite. Nearby, cornflower-blue kyanite crystals occur in muscovite schist. These kyanite blades average 1 inch in length, and reach a maximum of 6 inches at the nearby Big Chief 1 and 2 prospects. Some light-blue kyanite also occurs in pegmatite, and light-green tourmaline(?) is associated with the kyanite schist. On the nearby Pinyon claims, disseminated emerald-green kyanite was reported in felsic rocks (Osterwald and others, 1966).

Holroyd Park. This occurrence is located in sections 7, 8, 17, and 18, T12N, R81W, and sections 12 and 13, T12N, R82W. A sillimanite gneiss west of Highway 230 near the Colorado-Wyoming state line contains silver-dollar size pods of sillimanite, quartz, and muscovite. This gneiss also contains layers of sillimanite-quartz-garnet-feldspar gneiss (Houston and Graff, 1995).

SW section 29, T13N, R83W. A kyanite-bearing pegmatite grades westward into a vermiculite deposit north of the old Broadway lead-zinc mine (Ferris, 1964). This pegmatite is located several miles south of Encampment.

APATITE (FLUORAPATITE)

Fluorapatite, a fluorine-bearing apatite with the general chemical formula [$Ca_5(PO_4)_3F$], forms colorless, yellowish-green, green, bluish-green, and blue, transparent to opaque, long prismatic hexagonal crystals with poorly developed basal cleavage. Unaltered crystals have a hardness of 5.

In Wyoming, fluorapatite has been found in some granitic pegmatites in the Granite Mountains. There are probably several unreported occurrences of fluorapatite in this region.

Granite Mountains

Black Mountain pegmatite. This pegmatite (see **SPODUMENE**) in the northern Granite Mountains contains some fluorapatite in association with a spodumene pegmatite.

Jeffrey City region. North of Jeffrey City (section 32, T31N, R91W), a small pegmatite located near the top of a granite hill has a core of white quartz with relatively common prismatic bluish-green fluorapatite crystals (**Figure 9, Plate 1**). The crystals are opaque to transparent with common fractures (W. Dan Hausel, personal field notes, 1998). The fluorapatite was confirmed by X-ray diffraction (XRD) analysis (Robert W. Gregory, personal communication, 1998).

BARITE

Barite ($BaSO_4$) crystals can provide attractive additions to mineral collections, although barite is not considered to be a gemstone due to its relatively low hardness (3 to 3.5). Because of its high specific gravity (4.5), massive barite has been used as a weighting agent in drilling muds as an aid in blowout prevention. Its high specific gravity produces a very noticeable heft, which greatly aids in the identification of massive specimens.

Barite, when found in crystals and crystal clusters, can produce attractive mineral specimens. It crystallizes in the orthorhombic crystal system and may form aggregates or divergent groups of tabular crystals known as *barite roses*. Barite has perfect basal cleavage with a prismatic cleavage at right angles to the basal cleavage, and will sometimes form white masses with distinct right angle cleavage. Tabular white, yellow, gray, blue, red, or brown, opaque, translucent and transparent crystals have been reported.

Barite is found as a gangue mineral in some metallic veins, and is sometimes found with calcite veins in limestone. It has also been found in hot spring deposits. Some of the better specimens found in Wyoming have come from the Shirley Basin, where attractive, light-blue barite crystals are found.

Bighorn Basin

Shoshone Canyon. Small radial clusters of white barite crystals are found in the SE section 5, T52N, R102W, about 4 miles west of Cody. Some of the crystals from this area are up to one inch in length (Wayne M. Sutherland, personal field notes, 1988). The barite is associated with paleo hot spring deposits of Quaternary age and solution cavities in the Mississippian Madison Limestone. *Recommended map: U.S. Geological Survey topographic map of the Cody 1:100,000-scale Quadrangle.*

Medicine Bow Mountains

New Rambler mine. A barite occurrence is reported in the SW section 33, T15N, R79W, of the Medicine Bow Mountains. Fine-grained to massive pyrite was reported with barite crystals at the New Rambler Mine west of Rob Roy Reservoir (Osterwald and others, 1966). The New Rambler mine was developed as a copper mine, but also produced some gold, silver, platinum, and palladium (Hausel, 1993a).

Shirley Basin

White barite concretions are reported from Shirley Basin in southeastern Wyoming. These often are weakly fluorescent under long-wavelength ultraviolet light. Some very attractive barite crystals have also been found along Sheep Creek in the Mine Hills area.

Mine Hills. Some of the better barite specimens in Wyoming have been found in the Mine Hills area (section 10, T26N, R75W) along the southeastern margin of Shirley Basin (**Figure 10, Plate 1**). The barite occurs as attractive light-blue, transparent to translucent, tabular barite crystals that are highly sought by mineral collectors. The crystals are found along Sheep Creek northeast of Medicine Bow (Hausel, 1987) (**Figure 11**). Associated with manganese and jasper, the barite is found with calcite in vugs that occur in sandstone of the Casper Formation (see **MANGANITE–PSILOMELANE**). *Recommended map: U.S. Geological Survey topographic map of the Laramie Peak 1:100,000-scale Quadrangle.*

Sierra Madre

Hog Park. A pod-like body of barite, 40 feet wide by 300 feet long, associated with opal(?) was described by Osterwald and others (1966) around the NW section 2, T12N, R85W, about 15 miles southwest of Encampment (**Figure**

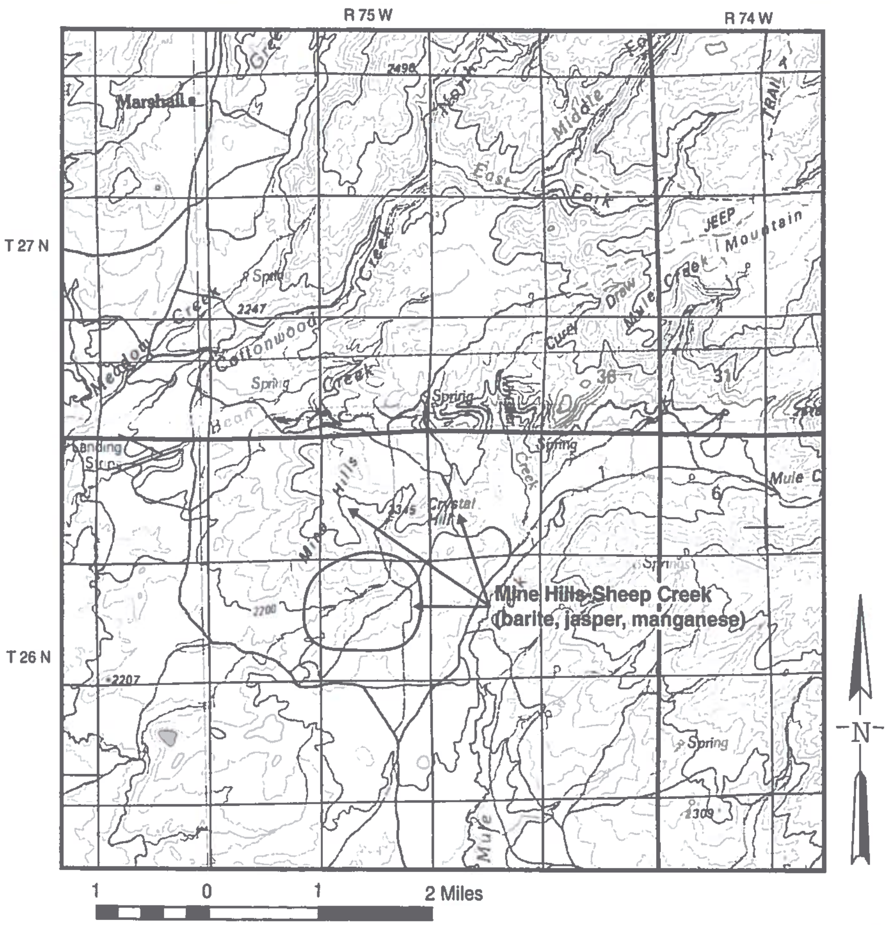


Figure 11. Location map of the Mine Hills-Crystal Hills-Sheep Creek area, adapted from U.S. Geological Survey 1:100,000-scale topographic map of the Laramie Peak Quadrangle.

7). The barite was described as occurring along the northern edge of a shear zone in contact with red quartz monzonite. *Recommended map: U.S. Geological Survey topographic map of the Saratoga 1:100,000-scale Quadrangle.*

BERYL

Beryl, a beryllium-aluminum-silicate with the general formula of $Be_3Al_2(Si_6O_{18})$, typically occurs as simple hexagonal prisms $m[1010]$ terminated by flat pinacoids with perfect basal cleavage. Even though opaque varieties of beryl have no intrinsic value except as beryllium ore (when found in high enough concentrations), many low-quality crystals produce excellent museum-quality samples due to their excellent crystal habit and often large size (some crystals are very large, and individual specimens weighing up to 200 tons have been recovered from pegmatites outside of Wyoming) (Vanders and Kerr, 1967). Beryl has a relatively high hardness (H=7.5 to 8 on Mohs scale) and a relatively average specific gravity (2.66 to 2.83). Transparent varieties of beryl produce some of the more attractive and valuable gemstones (**Table 1**).

Table 1. Varieties of transparent gemstone beryl.

Color	Terminology
light-blue	aquamarine
green	emerald
yellowish	golden beryl (helidor)
pink	morganite
colorless	goeshenite
red	red emerald

Most beryl found in Wyoming occurs as common opaque, greenish-yellow beryl associated with granite pegmatite. Gemstone varieties of beryl are less common. The only variety of gemstone beryl that has positively been found in Wyoming is light-blue transparent to translucent aquamarine. However, some small, light- to grass-green, transparent beryl was reportedly found in the Sierra Madre of southeastern Wyoming (Larry Clark, personal communication, 1996). Although the stones were verified as beryl, the locality cannot be verified because the exact location was not disclosed.

Red beryl, another gemstone variety, has not been reported in Wyoming but has been found in topaz rhyolites in the Wah Wah Mountains near Delta, Utah. This gemstone ranges from clear transparent to translucent rose to magenta to blood red. Only a few rhyolite-hosted beryl deposits have been reported in the world. These include the Thomas Range, Utah; Black Range, New Mexico; and possibly the East Grants Range, New Mexico and San Louis Potosi, Mexico (Keith and others, 1994).

Beryl occurrences in Wyoming have ranged from crystals less than one inch long to well-formed crystals more than a foot in length. One large specimen of transparent to translucent aquamarine was found in the Anderson Ridge area of South Pass several years ago (Hausel, 1991a). However, most other beryl found in the Anderson Ridge area has been poor quality, yellowish-green and opaque. Transparent beryl has been reported from pegmatites along Hoodoo Creek in the southern part of Copper Mountain in the Owl Creek Mountains near Shoshoni, and some aquamarine has been reported in the southeastern Seminoe Mountains (Cheyenne Gem and Mineral Society, 1965). Opaque beryl has been reported in several pegmatites in the Hartville uplift in eastern Wyoming. Some of the better specimens of opaque beryl have been found on Casper Mountain in central Wyoming (**Figure 12, Plate 1**).

Bighorn Mountains

An unverified report indicated that some aquamarine beryl may have been found in the Bighorn Mountains near Sheridan (Sutherland, 1990). However, no specific details were given.

Black Hills

Tin-bearing pegmatites occur in the Tinton district of the Black Hills of South Dakota, immediately east of the Mineral Hill district, Wyoming. Beryl is reported as an accessory mineral in the Tinton pegmatites. *Recommended map: U.S. Geological Survey topographic map of the Sundance 1:100,000-scale Quadrangle.*

Mineral Hill district. Beryl-bearing pegmatites reportedly extend from the Tinton district into sections 21, 28, and 33, T51N, R60W, in Wyoming (Hess and Bryan, 1938; Smith and Page, 1941). Amethyst, gold, silver, and jasper have also been reported in the Mineral Hill area (Hausel, 1989, 1997).

Granite Mountains

Barlow Gap

This area may be of interest to the collector since the two localities described below are new discoveries. *Recommended map: U.S. Geological*

Survey topographic map of the Rattlesnake Hills 1:100,000-scale Quadrangle.

NW NE section 25, T31N, R88W. Several translucent, light-blue beryl crystals are enclosed in quartz and feldspar in a pegmatite with a maximum width of 20 feet (Wayne M. Sutherland, personal field notes, 1998). The beryl crystals are up to 1.5 inches in length.

NW NW SE section 26, T31N, R88W. In the Barlow Gap area, light-blue, translucent beryl crystals were recovered from a 20-foot-wide pegmatite. The pegmatite crosscuts the foliation in the country rock schist. One crystal was more than 1 inch in diameter (Wayne M. Sutherland, personal field notes, 1998).

Hartville uplift

Beryl-bearing granitic pegmatites are reported in both the Haystack Range area, southern Hartville uplift, and in the Rawhide Buttes area, northern Hartville uplift (**Figures 3** and **13**). Millgate (1965) described pegmatites in the Haystack Range as including both fine- and medium-grained granitic pegmatites composed of quartz, microcline, perthite, plagioclase, muscovite, tourmaline, biotite, garnet, apatite, and beryl. Many of the beryl-bearing pegmatites were found in the N/2 N/2 section 36, and in sections 25, 26, and 35, T28N, R65W.

Where mineralized, the beryl content of the pegmatites generally is less than 2% by volume (Hanley and others, 1950). Even at such low grades, some beryl was mined in the past. Millgate (1965) reported at least 150 pounds of hand-sorted beryl was produced from one pegmatite; crystals up to 4 feet long were found at another location (Sterrett, 1923). Much of the reported beryl appears to be common variety beryl. No gem-quality beryl is known to have been found in the region.

Haystack Range

This area is located in the Garnet Hill-McCann Pass area, 6 to 8 miles northeast of Guernsey. *Recommended map: U.S. Geological Survey topographic map of the Torrington 1:100,000-scale Quadrangle.*

Chicago and Ruth pegmatites. The Chicago pegmatite (SW NE SE section 35, T28N, R65W) contains light-cream to whitish-green euhedral beryl in the wall zone. The mineral grains range from 0.5 to 4 inches in diameter, and are often cut by quartz stringers. Similar yellow-white to light-green beryl crystals are reported at the Ruth pegmatite 600 feet south of the Chicago

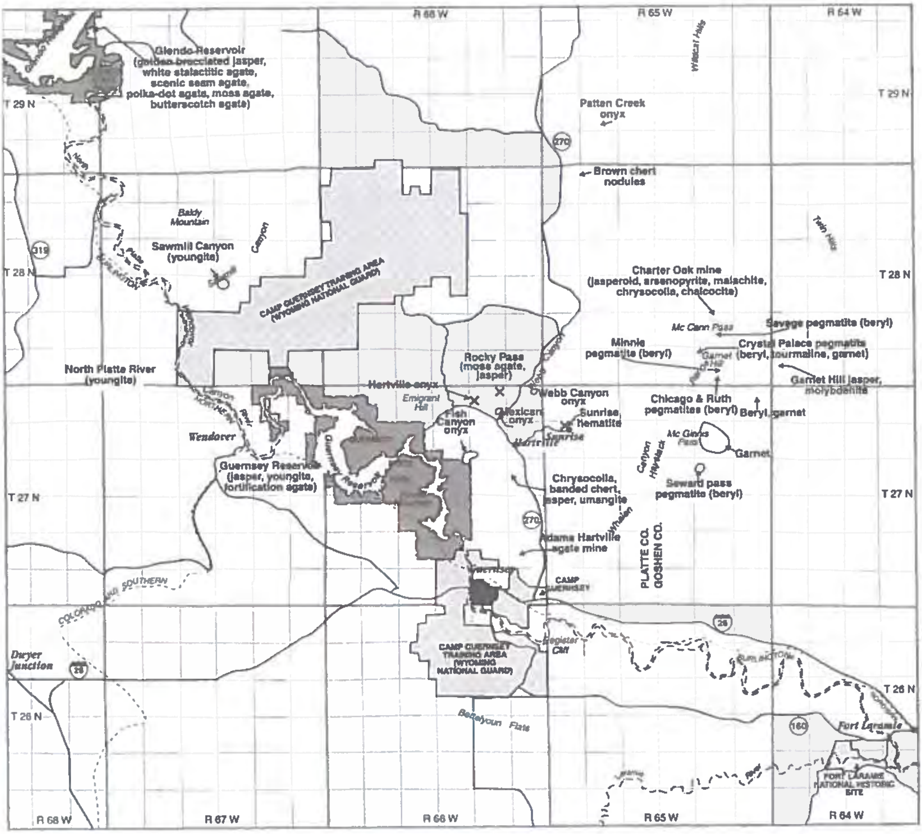


Figure 13. Mineral and rock localities in the Hartville uplift (adapted from U.S. Geological Survey topographic map of the 1:100,000-scale Torrington Quadrangle).

pegmatite. Hanley and others (1950) reported that these crystals ranged from 2 to 8 inches in diameter.

Crystal Palace pegmatite. The Crystal Palace claim (NE section 34 and section 35, T28N, R65W) was staked on a pegmatite along the section line between sections 34 and 35. The 6- to 18-foot-wide pegmatite has some beryl, with feldspar, quartz, muscovite, tourmaline, and garnet (Sterrett, 1923).

Minnie pegmatite. The Minnie pegmatite (section 35, T28N, R65W) hosts beryl crystals up to 4 feet in length (Sterrett, 1923). Several other pegmatites in the vicinity of the Minnie pegmatite also contain accessory beryl (Osterwald and others, 1966).

Savage pegmatite. This occurrence is located in NE SW section 26, T28N, R65W. The Savage deposit contains bluish-green beryl in a 10-foot-wide pegmatite (Sterrett, 1923). Hanley and others (1950) reported that 0.5- to 5-inch-diameter crystals of beryl, with an average diameter of less than one inch, were found. The beryl is found in clusters separated by zones of barren pegmatite.

Seward Pass. This occurrence is in NW section 14, T27N, R65W. Beryl occurs in aggregates in coarse-grained quartz. Approximately 150 pounds of beryl were mined from this locality (Millgate, 1965).

Section 1, T27N, R65W. White to light yellowish-green beryl crystals, 0.25 to 1 inch in diameter, were reported from a pegmatite at this location (Wilson, 1951a).

Rawhide Buttes

The Rawhide Buttes area is located 3 to 10 miles south of Lusk. *Recommended map: U.S. Geological Survey topographic map of the Lusk 1:100,000-scale Quadrangle.*

Sections 2 and 3, T31N, R64W. A 90- by 400-foot-long pegmatite contains beryl crystals up to 6 inches in diameter (Osterwald and others, 1966).

Section 3, T31N, R64W. Beryl crystals up to 6 inches long and 2 inches in diameter are reported in a 20- by 300-foot-long pegmatite (Osterwald and others, 1966).

Section 14, T31N, R64W. Pegmatite in biotite schist country rock contains minor beryl. The pegmatite is 15 feet wide and 120 feet long. The beryl is reported in crystals up to 2 inches in diameter and a foot in length and is more common near the contact of the pegmatite with the country rock (Osterwald and others, 1966).

Section 34, T32N, R64W. A 60-foot-wide pegmatite, which was traced for 100 feet along strike, contains beryl. Some of the crystals are 3 inches in diameter (Osterwald and others, 1966).

Laramie Mountains

Pegmatites with accessory beryl are reported from scattered localities in the northern Laramie Mountains. The crystals vary from millimeter size to 3 feet in length.

Northern Laramie Mountains

Recommended maps: U.S. Geological Survey topographic maps of the Casper and Laramie Peak 1:100,000-scale quadrangles.

Big Chief pegmatite. Much of this pegmatite is formed of quartz and orthoclase with minor plagioclase and muscovite. The pegmatite lies in contact with a hanging wall actinolite schist, and a footwall of hornblende schist. Small (<1 inch) pale-blue beryl crystals occur near the pegmatite in fractures in the actinolite schist (Osterwald and others, 1966). The deposit is located in sections 9 and 16, T25N, R71W, near Owen Creek, west of Wheeler Flat, about 6 miles north of Palmer Canyon (**Figure 14**).

Casper Mountain. Most of these pegmatites are located in sections 17, 18, 19, and 20, T32N, R79W. According to Burford and others (1979) two types of pegmatites are found in the Precambrian supracrustal rocks on Casper Mountain south of Casper (**Figure 15**). These are simple pink and simple white pegmatites. The pink pegmatites are dikes with varying amounts of microcline, plagioclase, and smoky quartz with some accessory muscovite and biotite. The white pegmatites, which intrude the pink pegmatites, consist of microcline, plagioclase, and quartz with accessory muscovite and yellow-green beryl. Beckwith (1939) also reported that minor schorl (black opaque tourmaline) and garnet were found in some of the pegmatites.

Catherine No. 1. This pegmatite lies on Casper Mountain south of the Hogadon ski area, and is accessible from improved graded roads. This pegmatite is a white pegmatite with microcline, plagioclase, quartz, and minor yellow-green beryl (**Figure 12, Plate 1**). Beryl crystals up to 4 inches in diameter and 3 feet in length have been found in this pegmatite (Harris and Hausel, 1986). Two tons of hand-picked beryl, along with several tons of feldspar, were mined from this property in 1956 (Hausel and Glass, 1980).

Duck Creek. This occurrence is in section 34, T24N, R72W. A tiny aquamarine beryl (< 1mm) was recovered from stream sediment concentrates by the Wyoming State Geological Survey (Hausel and others, 1988). The source of the beryl is unknown, but suggests the presence of an undiscovered beryl

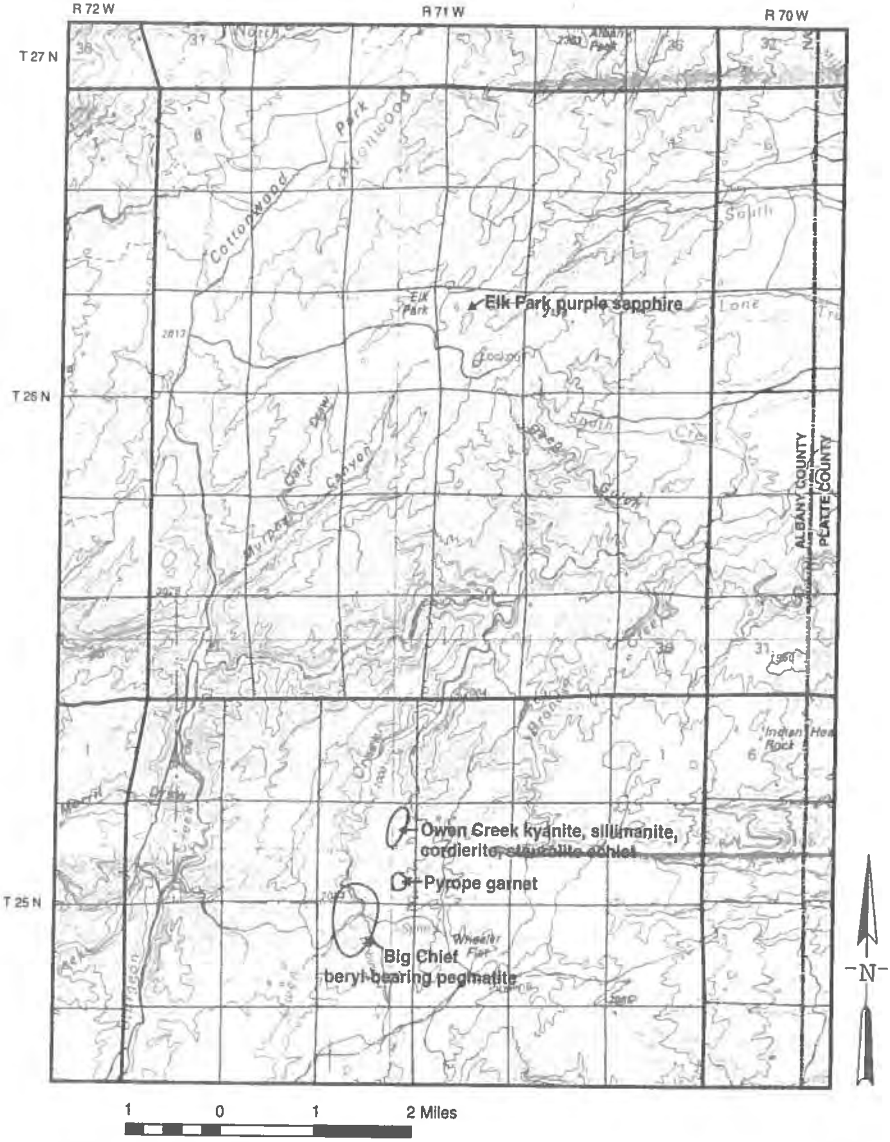


Figure 14. Location map of the Owen Creek-Big Chief-Elk Park mineral occurrences, adapted from U.S. Geological Survey 1:100,000-scale topographic map of the Laramie Peak Quadrangle.

pegmatite somewhere upstream.

Esterbrook district. Greeley (1962) reported that both apatite and beryl were associated with two zoned, northeast-trending pegmatites north-northeast of Esterbrook (**Figure 16**) in NW section 34, T29N, R71W. The pegmatites are both vertical, 300 feet long, and 2 to 5 feet wide (Osterwald and others, 1966). Yellow-green apatite up to 1 inch in diameter is a minor constituent of the pegmatites. Beryl forms less than 1% of the granitic pegmatites and

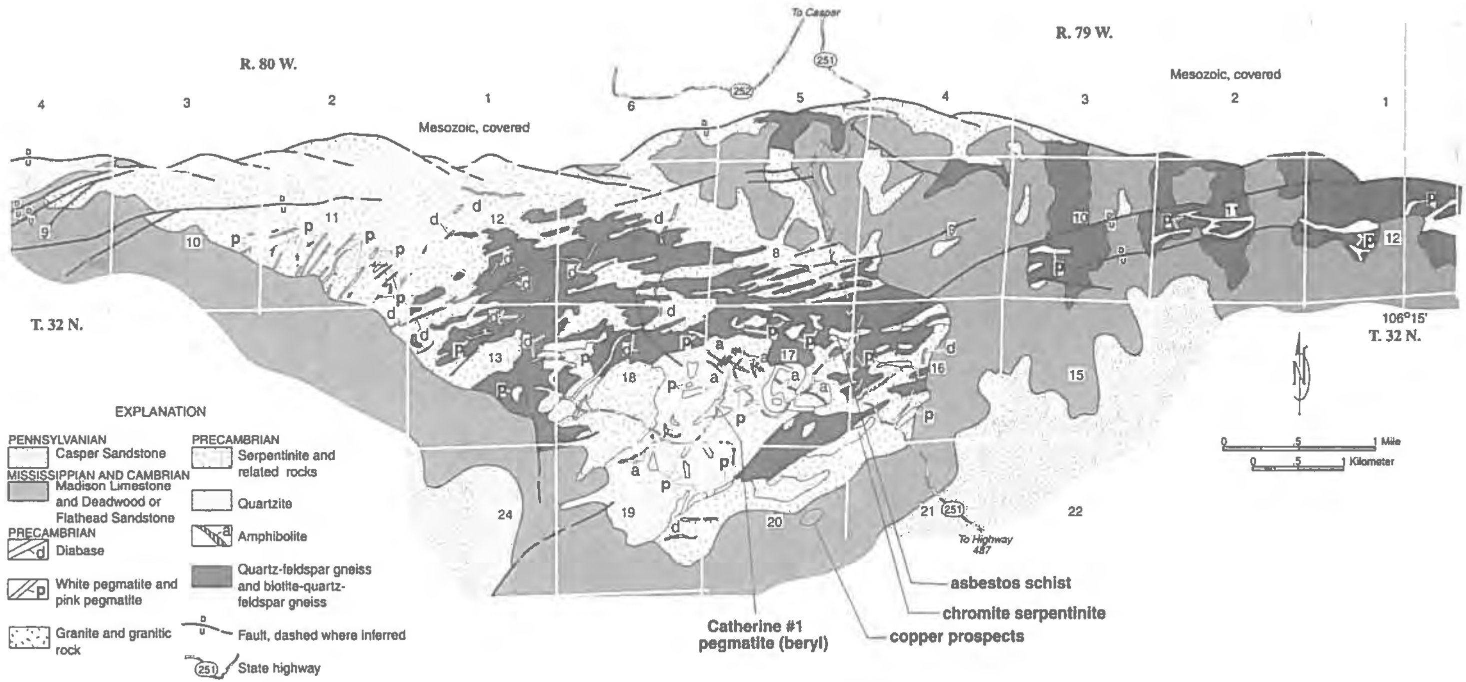


Figure 15. Generalized geologic map of Casper Mountain showing pegmatite localities (modified from Burford and others, 1979).

occurs in crystals from 0.25 to 3 inches in diameter. The beryl varies from pale-white to light-green with a brownish-colored skin on the exterior of the mineral, which is the result of weathering.

Jasper Mine. Copper is reported in fracture-fillings near the top of the Flathead Formation (Cambrian) in the LaPrele district, northern Laramie Mountains, Converse County (see Hausel, 1997a). The exact location of this

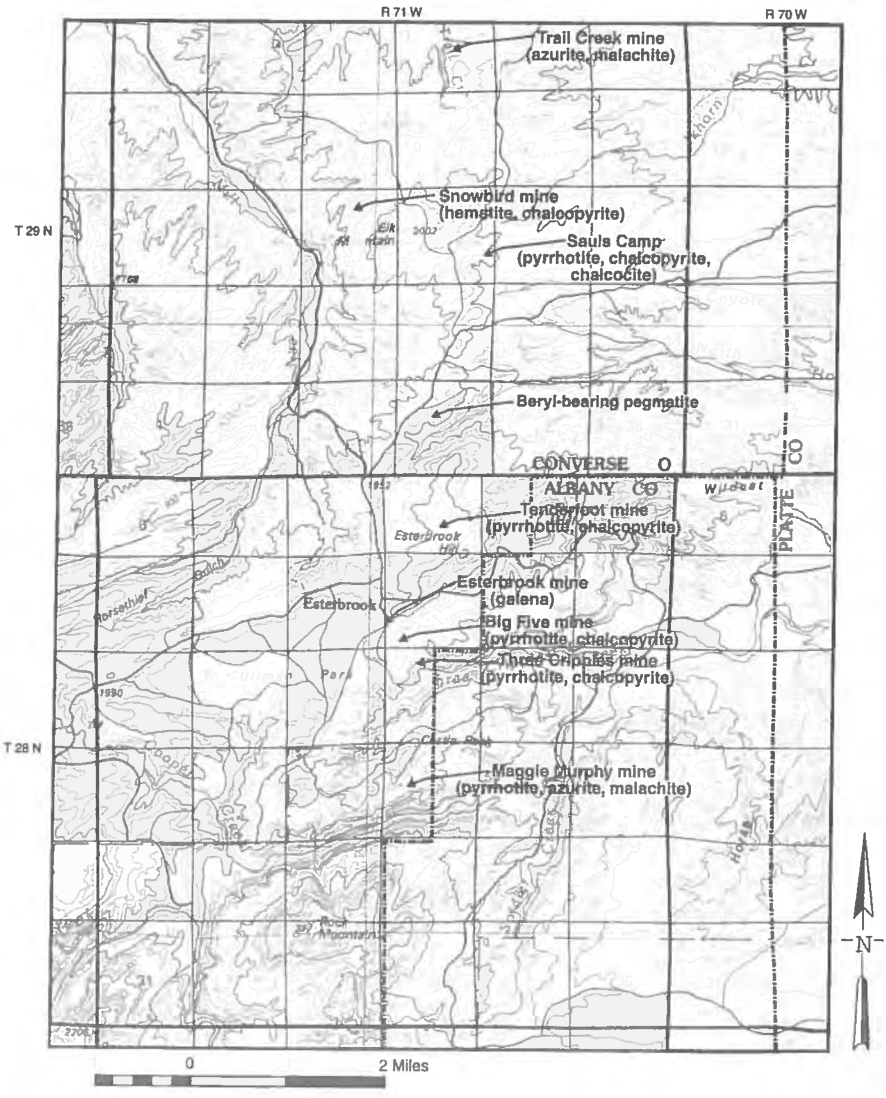


Figure 16. Location map showing occurrences of beryl and ore minerals in the Esterbrook area, adapted from U.S. Geological Survey 1:100,000-scale topographic map of the Laramie Peak Quadrangle.

mine is not known. Nearby, beryl was produced from a granite pegmatite which also contained mica, garnet, lepidolite, and bismuth (Osterwald and others, 1966).

Schundler-Glenrock. Located in section 29, T32N, R75W, this feldspar deposit contains a few beryl crystals in pegmatite hosted by granitic country rock (Smith, 1953; Osterwald and others, 1966).

Southern Laramie Mountains

State Line district. Beryl is reported in pegmatites in sections 2, 3, 4, 7, 9, 16, 18, and 19, T12N, R72W. Most of the pegmatites in this area are small, scattered intrusives with rare beryl (Hausel and others, 1981). Many of the pegmatites lie east of U.S. Highway 287. A few quarries were developed for feldspar in the 1940s in some of these pegmatites. Some of the quarries are still visible to the east of the highway. *Recommended map: U.S. Geological Survey topographic map of the Laramie 1:100,000-scale Quadrangle.*

Medicine Bow Mountains

Three pegmatites in the southern Medicine Bow Mountains and pegmatites in the Big Creek district of the western Medicine Bow Mountains are reported to contain beryl. No gem material has been reported in any of these. *Recommended map: U.S. Geological Survey topographic map of the Saratoga 1:100,000-scale Quadrangle.*

Big Creek district. Beryl was reported by Harris and others (1985) in the Big Creek district (T13N, R81W) on the west side of the Medicine Bow Mountains (**Figure 17**). According to Houston (1961), two general types of pegmatites are recognized in the district. One variety is a simple feldspar-quartz pegmatite, with accessory biotite, garnet, muscovite, magnetite, and ilmenite, that is conformable to the strike of the country rock amphibolite gneiss and schist. The second variety of pegmatite shows cross-cutting relationships to the country rock foliation, and has poorly developed zonation with a quartz-rich core near the center of the pegmatite and graphic granite on the outer border. Mineralogically, the second type of pegmatite consists of feldspar and quartz with accessory garnet, tourmaline, biotite, muscovite, and fluorite, and rare monazite, allanite, euxenite, and columbite. A third uncommon type of pegmatite at the Big Creek mine (NW section 9, T13N, R81W) is conformable to the country rock, contains some copper mineralization, and is relatively complex mineralogically.

Ione claim. The Ione claim lies west of the Muscovite claim in section 32,

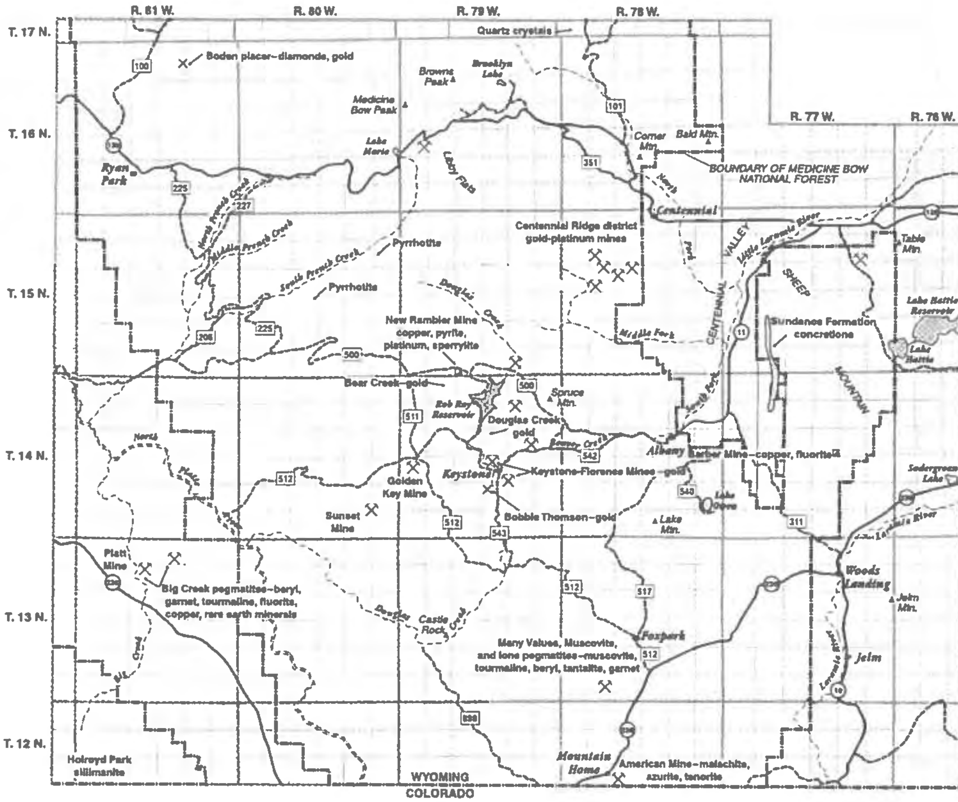


Figure 17. Rock and mineral localities in the Medicine Bow Mountains (adapted from U.S. Forest Service, 1998, 1:126,720-scale map of Medicine Bow National Forest).

T13N, R78W. This property also consists of a granite pegmatite dike with some beryl (Beckwith, 1937).

Many Values prospect. This prospect is located in NE section 32, T13N, R78W, southwest of Foxpark and about one mile west of Highway 230 (**Figure 17**). The Many Values pegmatite strikes N50°E, dips 85°NW, and has a surface exposure of 15 by 150 feet. Prospect pits developed in the pegmatite exposed a feldspar-rich core zone.

About 75 feet north of the main prospect is a second pegmatite that is apparently not connected to the main body. This second pegmatite is a feldspar-quartz-mica pegmatite which strikes northerly and has a vertical dip.

Muscovite is abundant near the hanging wall in the main pegmatite. Some of the muscovite books are speckled light-green with *magnetite* (magnetite is typically black, metallic and oxidizes to a rusty reddish-brown). Several tons of mica with two tons of industrial quality beryl were mined from this property prior to 1942. The pegmatite also contains small *tantalite* crystals (hard, black, submetallic minerals often with an iridescent tarnish and a short, prismatic or tabular habit), minor accessory *fergusonite(?)* (a rare-earth tantalite), and pink euhedral and orange subhedral garnets (Osterwald and others, 1966).

Muscovite claim. The Muscovite claim is located in section 32, T13N, R78W, west of the Many Values prospect. The Muscovite deposit consists of a granitic pegmatite dike, which strikes N50°E and dips vertically, cutting Precambrian metadiabase, hornblende schist, and gneiss. The pegmatite averages 40 feet wide and has a 600-foot strike length.

Green beryl is found along fractures in the wallrock associated with tantalite-columbite crystals. In places, quartz and feldspar show graphic textures. The pegmatite contains microcline crystals several inches in diameter and muscovite books up to a foot wide. Andradite garnet [$Ca_3Fe_2(SiO_4)_3$] is found as a minor accessory mineral (Osterwald and others, 1966).

Owl Creek Mountains

The Copper Mountain district in the Owl Creek Mountains lies northeast of Shoshoni and southeast of Thermopolis in northwestern Wyoming (**Figure 3**). Copper Mountain hosts several pegmatites. The core of the district is part of an ancient supracrustal terrane formed of metapelites (see **ANDALUSITE, KYANITE, SILLIMANITE, STAUROLITE**), amphibolites, felsic schists, and banded iron formation intruded by granite (**Figure 18**).

In addition to pegmatites, a variety of other minerals are found in the district. For example, near the eastern margin of Copper Mountain, the DePass copper mine contains a huge mine dump formed of cupriferous metabasalt and quartz. Near the western part of the district, the Gold Nugget mine was developed on a quartz vein with some pyrite and minor amounts of gold. Garnets, scheelite, and several other minerals have also been found in this region. A detailed geologic map showing many of the old mines in the district is available in Hausel, Graff, and Albert (1985). *Recommended maps: U.S. Geological Survey topographic maps of the Lysite and Riverton 1:100,000-scale quadrangles.*

Copper Mountain district. This district is underlain by Archean metamorphic rocks intruded by granite and granitic pegmatite (Hausel, Graff, and Albert, 1985). The metamorphic rocks include amphibolite, banded iron formation, quartzofeldspathic gneiss, biotite-chlorite-epidote schist, quartzite, quartz-mica schist, and porphyroblastic mica schist. The porphyroblasts

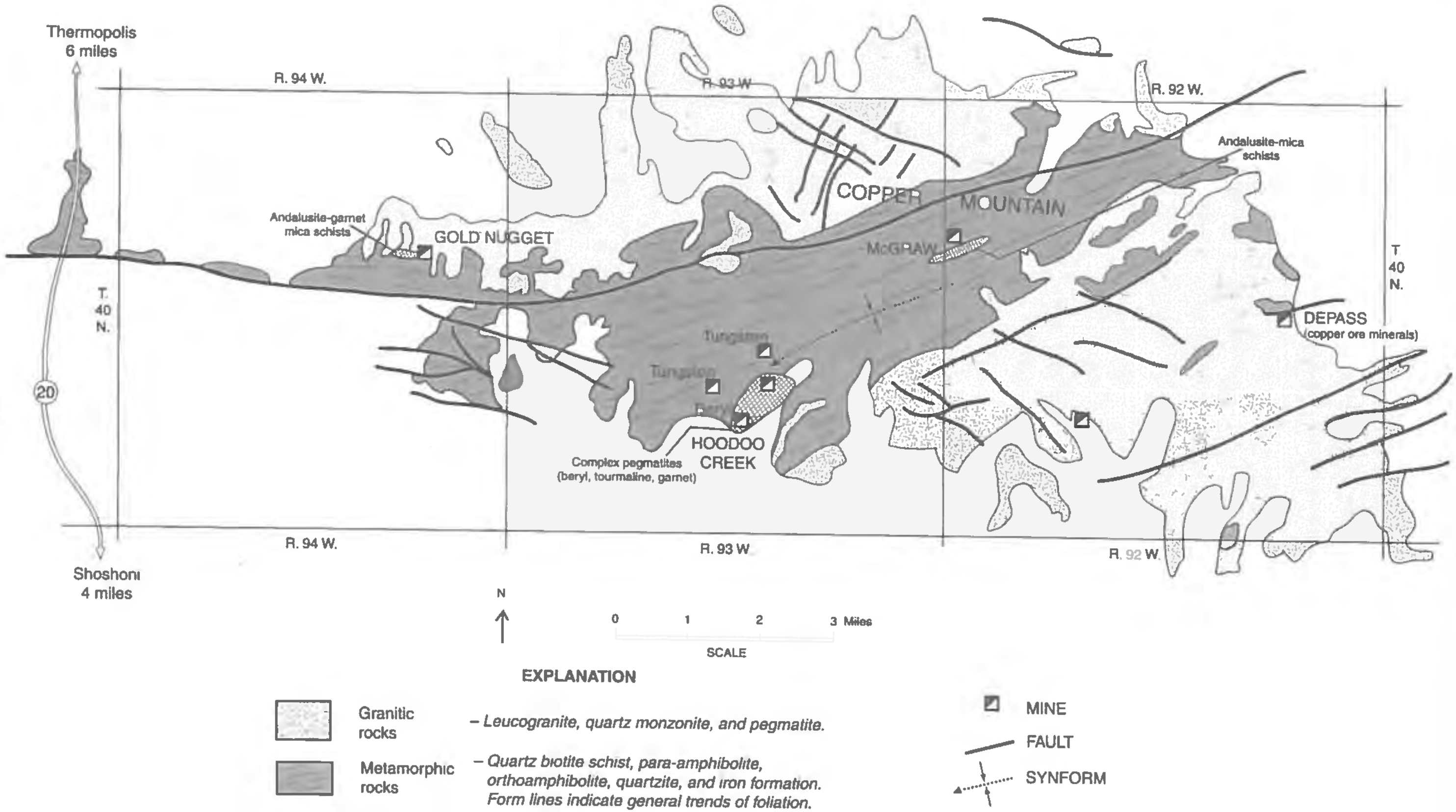


Figure 18. Map of mineral occurrences in the Copper Mountain district (modified from Hausel and others, 1985).

include andalusite, cordierite, sillimanite, and garnet, although none of these have been reported as gem quality.

The majority of the pegmatites found on Copper Mountain occur along the southern margin of the district in the vicinity of Hoodoo Creek (sections 22, 27, and 28, T40N, R93W). Two types of pegmatites occur in this region: (1) simple pegmatites composed of microcline, *bull quartz* (a miner's term for milky white, coarse grained, barren quartz), and muscovite mica; and (2) a more mineralogically diverse pegmatite with beryl, tantalite [$(Fe,Mn)(Ta,Nb)_2O_6$], tourmaline [$Na(Mg,Fe,Mn,Li,Al)_3Al_6(Si_6O_{18})(BO_3)_3(OH,F)_4$], garnet [$Fe_3Al_3(SiO_4)_3$], petalite, apatite [$Ca_5(PO_4)_3(F,Cl,OH)$], cleavelandite, and *lepidolite* (a pink, lithium mica) [$K_2Li_2Al_3(AlSi_7O_{20})(OH,F)_4$], in addition to microcline, bull quartz, and muscovite. Some pegmatites and quartzofeldspathic gneisses in this region also contain black tourmaline with some scheelite ($CaWO_4$), a white, opaque, massive mineral that brightly fluoresces light-blue under short-wavelength ultraviolet light.

Common variety beryl, including some aquamarine, was reported in some pegmatites. According to McLaughlin (1940), the beryl is found in association with *cleavelandite* (a variety of albite feldspar that occurs as white aggregates of flat, platy, crystals that usually form cleavable masses) and muscovite in zoned pegmatites. The beryl-bearing zone is found between a quartz-rich core and the hanging wall of the pegmatite. The beryl is typically light-green to pale blue and occurs as prismatic crystals with some anhedral masses. The grain size ranges from 0.03 inch to more than 7 inches in diameter (McLaughlin, 1940).

Wind River Range

Beryl has been reported in pegmatites in both the northern and southern parts of the Wind River Range in western Wyoming.

Northern Wind River Range

Warm Springs. Beryl is reported in pegmatites adjacent to the Warm Springs fault zone in sections 3 and 10, T41N, R108W, near the northern end of the Wind River Range (Osterwald and others, 1966).

South Pass region, southern Wind River Range

The South Pass region is located south of Lander (**Figure 3**) and is considered to be a very good area to collect and prospect, as much of the area is underlain by public land. In addition to pegmatites, gold and other minerals are found nearby. *Recommended maps: (1) U.S. Geological Survey topographic map of the Lander 1:100,000-scale Quadrangle; (2) geologic map of the South Pass granite-greenstone belt (Hausel, 1991a); (3) geologic map* *of the South Pass City Quadrangle (Hausel, 1988a); and (4) geologic map of the Anderson Ridge Quadrangle (Hausel, 1986a).*

Anderson Ridge. The Anderson Ridge area is located in SW section 26, T29N, R101W, along the western margin of the South Pass granite-greenstone belt (see Hausel, 1991a). The area is accessible from unimproved roads a short distance west of State Highway 28.

An excellent aquamarine beryl crystal, along with some poor quality green beryl, was discovered in a pegmatite in the South Pass Granite along Fish Creek (Elmer C. Winters, personal communication, 1985). The aquamarine was more than a foot in length and about 3 inches in diameter. The specimen was extracted in two pieces.

The South Pass region is a good place to explore for other minerals as well as beryl. Most notable is gold (see **GOLD**). This area also has some old ghost towns and is an interesting region to search for old coins, gold nuggets, artifacts, and related materials.

Ts28 and 29N, Rs101 and 102W. Beryl is found in coarse-grained tourmaline-beryl granite pegmatites in the general area around Anderson Ridge. Six different pegmatite types were described in this area by El-Etr (1963) and Proctor and El-Etr (1968) with only one type exhibiting noticeable beryl content. Specific occurrences of beryl-bearing pegmatites are in the NW section 29, and in the NW and SW section 31, T29N, R101W. However, no gem varieties of beryl are reported at these locations.

CALCITE AND CALCITE ONYX

Calcite ($CaCO_3$) is a relatively soft mineral with a hardness of only 3, and can be scratched with a knife. Calcite is relatively light in weight, having a specific gravity of only 2.71. Because it is relatively soft, calcite is not a gemstone. However, specimens of calcite crystals, geodes filled with calcite, and calcite onyx often produce attractive rock and mineral specimens and lapidary samples.

Calcite may be clear, white, or an off-white color. Because of impurities, specimens of russet, pale pink, and rose-colored manganese-bearing calcite are sometimes found. Many specimens of calcite will fluoresce brightly under ultraviolet light, yielding red, pink, green, blue, or yellow fluorescence. It is also soluble in hydrochloric acid, and will vigorously effervesce in cold, dilute (10%), hydrochloric acid.

Calcite is hexagonal in crystal form and typically crystallizes as rhombohedral or scalenohedral crystals and as finely crystalline masses. It will sometimes crystallize as elongated, hexagonal, sand-sized crystals containing as much as 60% calcite sand (Vanders and Kerr, 1967). Clear specimens of crystalline calcite also show good double refraction. When clear calcite is placed on top of a dot written on a piece of paper, two dots will be apparent to the viewer due to double refraction.

Calcite may also occur in a form of onyx, known as *Mexican onyx.* This Mexican onyx appears similar to true onyx (a variety of cryptocrystalline quartz called chalcedony), although it is considerably softer. Calcite onyx occurs with alternating dark and light color bands as the result of deposition from spring waters saturated with calcite. The material, because of its softness, does not take as high a polish as true onyx; however, it can be easily carved. In many cases, collectors cut specimens of the calcite onyx and coat them with acrylic spray, producing very attractive bookends.

Calcite is also found in septarian concretions, which are rounded nodules of clay, silt, and limestone that have been fractured and recemented with calcite or siderite that fills cracks in the concretions. Many of these are well-cemented and may contain well-crystallized calcite and rarely quartz.

Septarian concretions have been reported in outcrops of the Cody Shale in several parts of the state including the flanks of the Bighorn Mountains and in the northern end of the Medicine Bow Mountains. Where found in the Cody Shale, the concretions typically occur in the unnamed lower shale member, the Carlile Shale Member, and in the Niobrara Shale Member.

The upper 90 feet of the Carlile Shale near Buffalo contains dark gray fossiliferous limestone concretions that average 1 foot in diameter. The shale sometimes contains veins of dark orange or yellow calcite. The lower 175 feet of the Niobrara Member may sometimes contain two or three beds with dark yellowish-orange, fossiliferous, silty septarian concretions with veins of light-yellow calcite (Mapel, 1959). Some septarian concretions from the Niobrara have measured up to 10 feet in diameter, although these are generally too fractured for lapidary use (Sutherland, 1990).

The collector should obtain a *Geologic Map of Wyoming* (Love and Christiansen, 1985) and any available 1:24,000-scale geologic maps to search for concretions in areas where the Cody Shale crops out.

Bighorn Mountains

Septarian concretions have been reported in the Cody Shale on the west side of the Bighorn Mountains near U.S. Highways 16 and 14A. Septarian concretions are also reported from Cody Shale outcrops in several general areas along the east flank of the Bighorn Mountains, including west of Interstate 25 near Kaycee. *Recommended map: U.S. Geological Survey* *topographic map of the Buffalo 1:100,000-scale Quadrangle.*

Burnett Creek area. Mapel (1959) reported finding scattered, dark gray, septarian concretions in the upper part of the lower shale member of the Cody Shale southwest of Buffalo and northeast of Crazy Woman Mountain in section 12, T49N, R83W. These concretions sometimes contain marine fossils.

Goshen Hole

Goshen Hole area. Good hexagonal sand calcite crystals are found in this area of eastern Wyoming (Norma Beers, personal communication, date unknown). These unusual crystals consist of hexagonal calcite with considerable sand incorporated during crystallization, such that they appear to be nodules of sandstone. In actuality, they are formed primarily of calcite and effervesce in dilute hydrochloric acid. Many specimens show intergrown crystals with some twins (**Figure 19, Plate 2**).

Hartville uplift

Mexican onyx is found at several locations in the Hartville uplift north of Guernsey (**Figure 13**). The onyx is found associated with both the Permo-Pennsylvanian Hartville Formation and the Mississippian-Upper Devonian Guernsey Limestone. Some of the onyx was mined from this area in past years. *Recommended map: U.S. Geological Survey topographic map of the Torrington 1:100,000-scale Quadrangle.*

Fish Canyon. This occurrence is in sections 10, 11, and 15, T27N, R66W. Some white, brown, and green calcite onyx in the Hartville Formation extends across the SE section 10, SW section 11, and NE section 15. The onyx reportedly occurs on the north side of Fish Canyon about a mile west of Hartville along the edge of Guernsey State Park. Similar onyx is also found in the Hartville Formation on an east-facing slope in the NE SE section 11 and on a northeast-facing slope in NE SW section 14 (Ray E. Harris, personal communication to Sutherland, 1990).

Hartville onyx mine. Brown and white Mexican onyx has been quarried from the north side of Long Canyon in the NE NE section 2, T27N, R66W (W.D. Hausel, personal field notes, 1988). Brown calcite onyx is also found in a quarry, known as the Hartville onyx mine, in the center of the NW section 2, T27N, R66W (Eloxite Corporation, 1971). A decorative stone known as zebra rock (a white rock with black spots) is also found in the quarry.

Similar brown Mexican onyx is also found on a southeast-facing slope of the Guernsey Limestone in the center of the SE section 2, T27N, R66W (W. Dan Hausel, personal field notes, 1988) (**Figure 20, Plate 2**).

Patten Creek area. Calcite onyx was found on a south-facing slope of the Guernsey Formation in the Patten Creek area (SW SE section 29, T29N, R65W) (Ray E. Harris, personal communication to Sutherland, 1990).

Webb Canyon. The Webb Canyon onyx is located north of the town of Hartville in NE section 1, T27N, R66W, and SW section 36, T28N, R66W. White Mexican onyx has been quarried from the Guernsey Formation from both the north and south sides of Webb Canyon (Sutherland, 1990).

Medicine Bow Mountains

Septarian concretions have been reported in the Niobrara Shale at the northern end of the Medicine Bow Mountains (Sutherland, 1990). *Recommended map: U.S. Geological Survey topographic map of the Medicine Bow 1:100,000-scale Quadrangle.*

Coad Mountain. This area is in section 36, T19N, R82W. Septarian concretions with black and white calcite are found in the lower part of the Niobrara Shale along the banks of Pass Creek on the northeastern side of Coad Mountain (Hayford, 1971).

CHALCEDONY (see QUARTZ)

CHROMIAN DIOPSIDE AND CHROMIAN ENSTATITE

Two rare emerald-green minerals that sometimes make very attractive gemstones are chromian diopside and chromian enstatite (Hausel, 1998c). *Chromian (or chrome) diopside*, a chrome-rich variety of diopside [$CaMg(SiO_3)_2$], typically has an exceptional emerald-green color due to the substitution of chromium (1 to 2.8%) for magnesium in its crystal lattice. The mineral has a hardness of 6, a specific gravity of 3.2 to 3.4, and forms good monoclinic crystals.

Chromian (or chrome) enstatite, a chrome-rich variety of enstatite ($MgSiO_2$), has a hardness of 5.5, a specific gravity of 3.1 to 3.3, and occurs as orthorhombic crystals with an emerald-green color similar to chromian diopside. Both chromian diopside and chromian enstatite have good cleavage and parting, and will typically produce well-formed crystals. Enstatite will form crystals with good square cross-sections when viewed down the c-axis of the crystal; diopside will have a similar cross-section but with a pair of parallel crystal surfaces that are slightly inclined, typical of monoclinic crystals.

Because of their relatively high specific gravity, these minerals can be recovered from stream sediments using a gold pan, as long as one does not pan too hard. During the 1980s, the Wyoming State Geological Survey collected more than 1600 panned samples while searching for kimberlite. The project identified about 300 "kimberlitic indicator mineral anomalies" in the Laramie and Medicine Bow Mountains in southeastern Wyoming, some of which contained chrome diopside.

What makes these minerals so rare is that they were formed under great pressure and temperature, deep within Earth's crust and upper mantle. To get these minerals to the surface, some unusual geological event(s) had to occur. Wyoming has been subjected to numerous catastrophic events during the geological past. The eruption of kimberlitic magmas was possibly related to one of these events. During the past, kimberlitic magmas rose rapidly along deep fractures and picked up fragments of Earth's upper mantle and lower and upper crust, erupting explosively at the surface as small, pipe-like diatremes and dikes.

Some unique, mantle-derived rock fragments trapped within the kimberlitic intrusives include pyroxenites, dunites, eclogites, lherzolites, wehrlites, and harzburgites. Some of these *xenoliths* and cognate nodules contained chromian diopside and enstatite, as well as other potential gemstones such as pyrope garnet and diamond. Since these minerals are associated with kimberlites and related igneous rocks (kimberlite is one of a few magmas that originates deep enough to bring these minerals to the surface), they have become known as *kimberlitic indicator minerals*, along with pyrope garnet, picroilmenite, and some chromites.

Chromian diopside and chromian enstatite can produce very attractive gemstones; however, the majority of these minerals are poor quality. But because of their rarity, whether they are gem quality or not, they make interesting collector's specimens. When transparent to translucent and relatively free of flaws and mineral inclusions, chromian diopside and chromian enstatite form striking, emerald-green to grass-green minerals that can be faceted into very attractive semi-precious gemstones.

Some facet-quality chromian diopside has been found in both the Colorado-Wyoming State Line district south of Laramie and in the southern Green River Basin, southwestern Wyoming. One specimen collected from the Sloan kimberlite in Colorado, was cut and produced a striking gemstone (Jack Murphy, personal communication, 1997). Several transparent to translucent specimens of chromian diopside, chromian enstatite, and pyrope garnet collected in the Green River Basin have also been cut into very attractive gemstones.

In the State Line district, approximately 40 diamondiferous kimberlites have been found that contain abundant kimberlitic indicator minerals including rare mantle nodules. Some specimens collected from these kimberlites include large chromian diopside megacrysts up to 2 inches in diameter, impressive pyrope-almandine megacrysts up to 5 inches in diameter, and eclogite and peridotite boulders up to 8 inches in diameter. The Iron Mountain district, about 50 miles to the north of the State Line district, contains several kimberlites with abundant kimberlitic indicator minerals that are typically smaller than those in the State Line district.

In the southern Green River Basin, hundreds of anthills have been identified that contain chromian diopside and enstatite, as well as beautiful red, reddish-pink, and yellowish-orange, transparent to translucent pyrope and pyrope-almandine garnet. Many of these are found in the vicinity of Cedar Mountain and Butcherknife Draw, south of Interstate 80 between the towns of Fort Bridger and Green River.

When gem-hunting in Wyoming, it is worthwhile to keep an eye out for chrome diopside and chrome enstatite, as these minerals can produce very attractive and beautiful emerald-colored gemstones, and could possibly lead to a diamond deposit. However, these minerals are extremely rare.

Green River Basin

The Green River Basin of southwestern Wyoming provides an excellent area to search for chromian diopside and enstatite as well as pyrope garnet. These kimberlitic indicator minerals are scattered over a relatively large area covering about 500 mi^2 (**Figure 21**). Much of the area is located on public lands. *Recommended maps: (1) U.S. Geological Survey topographic maps of Firehole Canyon and Evanston 1:100,000-scale quadrangles; and (2) General location map of known kimberlitic indicator mineral anomalies (see McCandless and others, 1995, p.138; Hausel and others, 1997).*

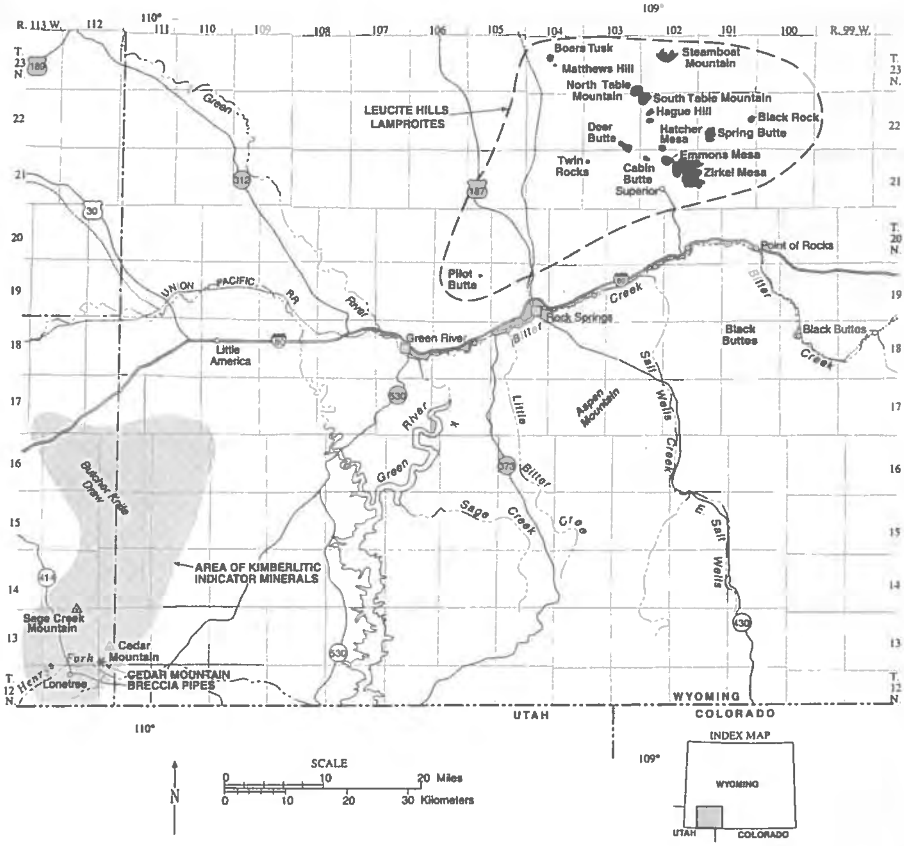


Figure 21. Index map of the southern Greater Green River Basin (modified from Hausel, Sutherland, and Gregory, 1995).

Big Dry Creek-Butcherknife Draw region. The Butcherknife Draw area (Ts14 and 15N, Rs111 and 112W) contains anthills armored with transparent to translucent chromian diopside, chromian enstatite, and pyrope garnet (**Figure 22, Plate 2**). Soils between the anthills also contain similar minerals. These continue to the north near Mud Spring Hollow and Moss Agate Cut (McCandless and others, 1995). Some of these indicator minerals have been cut into gemstones.

Cedar Mountain. Eleven cryptovolcanic breccia pipes were discovered by Richard E. Kucera along the southwestern flank of Cedar Mountain near the Utah border in Ts12 and 13N, R112W (Hausel and others, 1997). The pipes and associated dikes lie along a 5- to 10-mile-long, north-south-trending lineament in the Bridger Formation (Eocene). The pipes contain brecciated lithic fragments of the Bridger Formation, as well as numerous kimberlitic indicator minerals and some eclogite xenoliths. The indicator mineral assemblage includes chromian diopside, pyrope garnet, chromite, picroilmenite, and reportedly some diamonds (Richard E. Kucera, personal communication, 1997). Some indicator minerals from the breccia pipes are as large as 0.25 to 0.5 inch across (Carolyn Jones and Dave Freeman, personal communication, 1998). Many of the minerals are translucent to transparent (**Figure 23, Plate 2**).

Along the northwestern flank of Cedar Mountain, boulders of Bishop Conglomerate contain grains of chromian diopside and pyrope garnet. Both minerals have also been found in the Bishop Conglomerate on Hickey and Sage Creek mountains in Wyoming and Diamond Peak in northwestern Colorado (McCandless and others, 1995).

Laramie Mountains

Chromian diopside was found in several stream sediment sample concentrates in the Laramie Mountains (Hausel and others, 1988). The mineral grains recovered from the concentrates were primarily microscopic (<1 mm in diameter) and have no value to a collector, but they are useful in the exploration for kimberlite, and ultimately to discover indicator mineral sources. Tests conducted by Leighton and McCallum (1979) suggested that chrome diopside would transport only about 0.25 mile downstream from a kimberlite source before complete disaggregation. As a result, chromian diopside makes a good pathfinder mineral to search for kimberlite.

Central Laramie Mountains

A group of kimberlites intrude the Sherman Granite north of Farthing in the Laramie Mountains. These comprise the Iron Mountain kimberlite district, which lies 45 miles north of the State Line district (**Figure 24**). These kimberlites are located on state, federal, and private property. To the northwest of Iron Mountain, another kimberlite occurs in the Middle Sybille Creek area; farther north, numerous kimberlitic indicator minerals have been identified in the Elmers Rock greenstone belt. *Recommended maps: (1) U.S. Geological Survey topographic map of the Rock River 1:100,000-scale Quadrangle; (2) location maps of stream sediment samples (Hausel and others, 1988, plates 1 and 4); (3) general locality map of the Iron Mountain district (Hausel and others, 1997, p. 49); and (4) geologic map of the Sheep Rock area (Hausel and others, 1981, plate 2).*

Elmers Rock greenstone belt. One of the more impressive regions for abundant kimberlitic indicator mineral anomalies lies within the Elmers Rock greenstone belt north of Sybille Canyon in Ts21 to 24N, Rs69 to 73W. These anomalies were discovered by the WSGS. This greenstone belt could potentially host dozens of undiscovered kimberlites. Chromian diopside and pyrope garnet grains recovered from panned concentrates are typically less

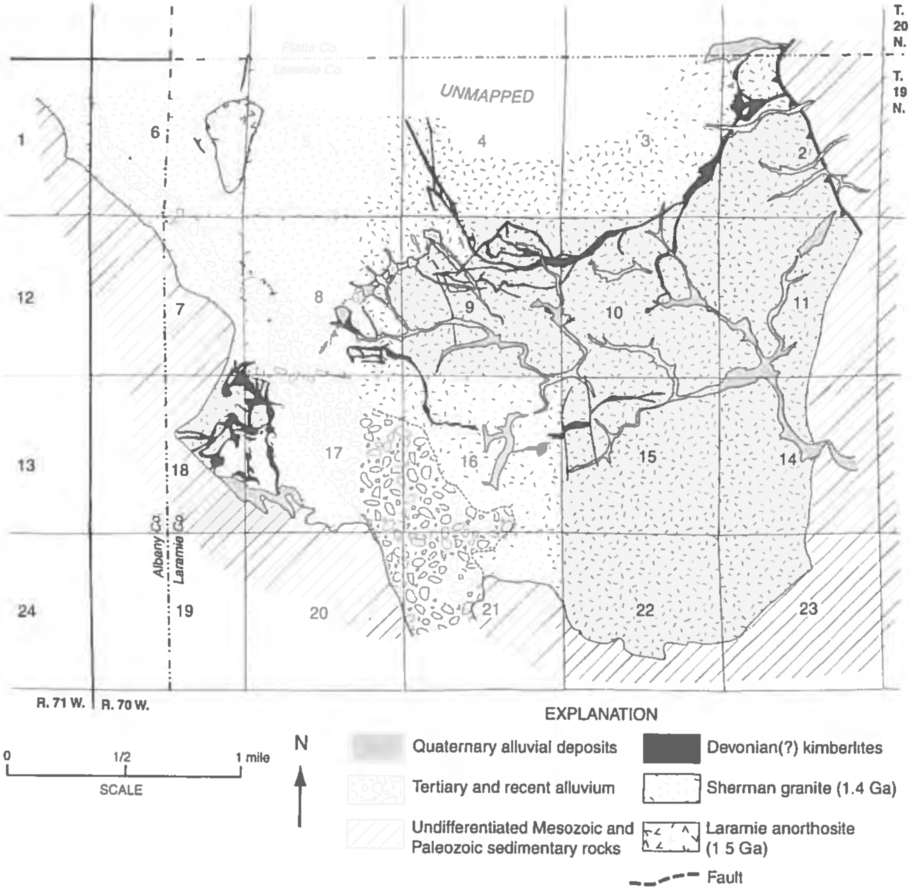


Figure 24. Location map of the Iron Mountain kimberlites (geology by Hausel, 1998e with additions from January, 2000).

than 1 mm in diameter; however, mineral trains of these indicator minerals could potentially lead to discovery of kimberlites (Hausel and others, 1988). The Elmers Rock greenstone belt is an Archean supracrustal belt formed of metasedimentary and metavolcanic rocks (Graff and others, 1982).

Iron Mountain kimberlites. These are located in parts of sections 2, 3, 7, 8, 9, 10, 15, 16, 17, and 18, T19N, R70W. Some of the Iron Mountain kimberlites crop out on the surface, and several are recognized by both vegetation anomalies and the presence of chromian diopside, pyrope garnet, and picroilmenite in the soils (**Figure 25, Plate 2**). The presence of kimberlitic indicator minerals and mantle nodules at Iron Mountain is less common compared to the State Line kimberlites (Hausel and others, 1997).

The Iron Mountain kimberlites can be separated into three different areas or complexes. A large, 2.5-mile-long dike-blow complex along the eastern margin of the district contains sporadic outcrops of hypabyssal facies kimberlite (see Hausel, 1998d for terminology) with distinct vegetation anomalies and blue ground between the outcrops. Kimberlitic indicator minerals are present in this dike-blow complex, but are relatively uncommon. The outcrops contain many excellent kimberlite rock hand specimens with black to red, rounded hematite, magnetite, and serpentine replacements of olivine phenocrysts and megacrysts. Many of these rocks also make a beautiful terrazzo.

The middle complex consists of a dike more than a mile long formed of silicified kimberlite breccia with carbonated kimberlite matrix enclosing abundant angular granite xenoliths. Kimberlitic indicator minerals are rare in this rock.

The western complex, which appears to connect with the eastern complex, consists of several connecting dikes and blows more than one mile in length. The few outcrops that occur along this complex consist of lower diatreme to upper hypabyssal facies kimberlite with relatively common kimberlitic indicator minerals. The indicator minerals include large megacrysts of picroilmenite and smaller pyrope and chromian diopside grains (W. Dan Hausel, personal field notes, 1997-98). Several hidden or buried kimberlites occur in the complex.

Middle Sybille Creek. A single kimberlite, known as the Radichal kimberlite, crops out along Middle Sybille Creek in section 30, T20N, R71W (Hausel and others, 1981). The kimberlite is relatively poor in chromian diopside as well as pyrope garnet, although picroilmenite is common.

Colorado-Wyoming State Line district

This district is one of the most important areas in the Laramie Mountains for chromian diopside and enstatite. About 40 diamond-bearing kimberlites (**Figure 26**) all contain some chromian diopside and enstatite; the relative abundance of these minerals varies from kimberlite to kimberlite, as well as within individual intrusives. The known kimberlites extend from near Tie Siding, Wyoming, to as far south as the Prairie Divide area in Colorado and are described below. *Recommended maps: (1) U.S. Geological Survey topographic maps and U.S. Bureau of Land Management surface and mineral management status maps of Ft. Collins and Laramie 1:100,000-scale quadrangles; (2) General location map of known kimberlites (see Hausel and others, 1997); (3) Preliminary (1:24,000-scale) geologic map of the Wyoming portion of the Colorado-Wyoming State Line district (see Hausel and others, 1981).*

Aultman 1 and 2 kimberlites. Two poorly exposed kimberlites occur along the northern margin of the State Line district in sections 5 and 8, T12N,

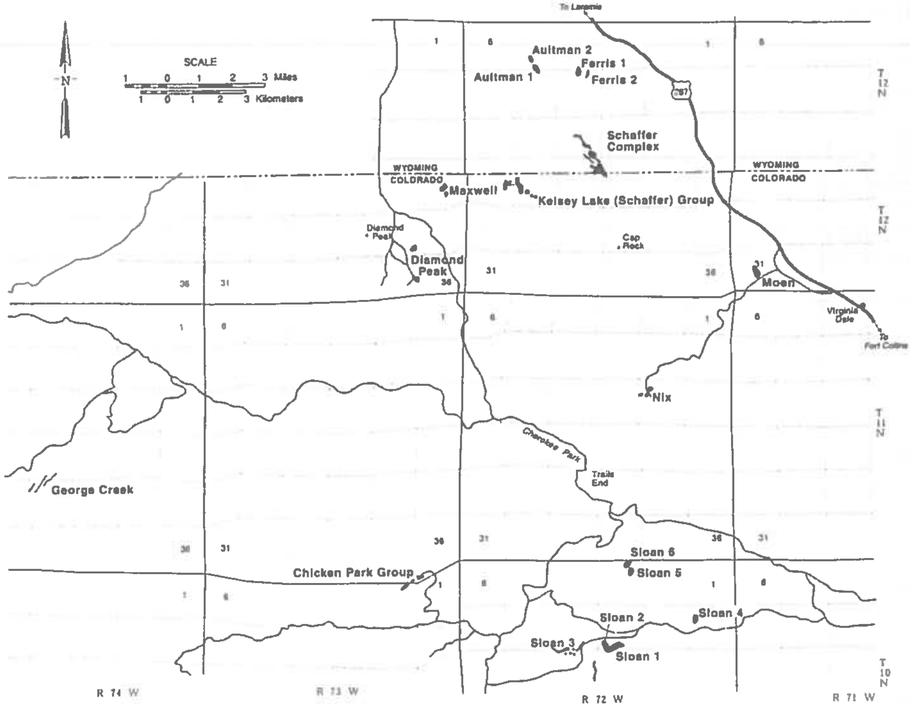


Figure 26. Location map of kimberlites within the Colorado-Wyoming State Line district (from Hausel, 1998d).

R72W. The Aultman 1 kimberlite was discovered in 1961 after several out-of-place boulders, cobbles, and pebbles of Silurian, Ordovician, and Cambrian sedimentary xenoliths were found in a 250- to 350-foot-diameter area surrounded by Precambrian granite. The xenoliths lie within a kimberlite pipe that was emplaced during the Early Devonian.

The Aultman 2 kimberlite was discovered in 1977 by the senior author based on the presence of kimberlitic indicator minerals and *blue ground* (a montmorillonite-carbonate-serpentine-rich soil that has a light blue-gray color) located northwest of the Aultman 1 kimberlite. During diamond exploration in this region in the early 1980s (both kimberlites yielded some diamonds), these kimberlites were trenched, leaving abundant chromian diopside and other kimberlitic indicator minerals exposed on the surface.

Chicken Park kimberlites, Colorado. The Chicken Park kimberlites are located in sections 35 and 36, T11N, R73W, and section 2, T10N, R73W, and include a group of small, poorly-exposed, intrusives. Although chromian diopside is relatively uncommon, picroilmenite, another kimberlitic indicator mineral, is relatively common and found scattered over the surface of these intrusives (W. Dan Hausel, personal field notes, 1994). *Picroilmenite* is a black, metallic mineral ($Fe,MgTiO_3$) with a relatively high specific gravity of 4.2.

Ferris 1 and 2 kimberlites. Two kimberlites, known as the Ferris 1 and 2, occur southeast of the Aultman kimberlites in section 9, T12N, R72W. The Ferris 1 kimberlite was discovered in 1960 based on abundant Silurian and Ordovician limestones scattered over a 350-foot-diameter circular area surrounded by Precambrian granite (Chronic and Ferris, 1963). The nearby Ferris 2 kimberlite was discovered years later and forms a small exposure of serpentinized hypabyssal-facies kimberlite porphyry (W. Dan Hausel, personal field notes, 1977). These kimberlites are located on private land and very little information is available.

Kelsey Lake, Diamond Peak, and Maxwell kimberlites, Colorado. These kimberlites are located in sections 24, 26, and 35, T12N, R73W; and sections 19 and 20, T12N, R72W. The Kelsey Lake kimberlites were originally part of the Schaffer kimberlites, and were later renamed. A few additional kimberlites were later discovered in the vicinity of Kelsey Lake (Coopersmith, 1993).

Two of the Kelsey Lake kimberlites were mined by open pit beginning in 1996, producing more than 9000 carats in diamonds, many of which were gem-quality stones (see **DIAMOND**). The kimberlites at Kelsey Lake also contain numerous transparent pyrope garnets. Chromian diopside is relatively uncommon compared to some other kimberlites in the district (W. Dan Hausel, personal notes, 1997).

The Maxwell and Diamond Peak kimberlites east of Kelsey Lake are outlined by vegetation anomalies (Carlson, 1983) but kimberlitic indicator minerals are uncommon at both localities (W. Dan Hausel, personal field notes, 1994).

Schaffer complex kimberlites. A group of kimberlite diatremes and blows, known as the Schaffer complex, is located in sections 16 and 21, T12N, R72W. The group includes the Schaffer 3, 5, 5A, 5B, 5C, 5D, 10, 12A, 12B, 13, 15, 16, 17, 18, 19, and 20. These all occur in the Wyoming part of the district (Hausel and others, 1981). A few additional Schaffer kimberlites were mapped on the Colorado side of the border (Eggler, 1967). Some of these, along with some new discoveries, were renamed the Kelsey Lake kimberlites (see Coopersmith, 1991, 1997).

The Schaffer kimberlites are deeply weathered and poorly exposed, and occur as sporadic blue ground associated with some vegetation anomalies (Hausel and others, 1979). However, because of trenching by Cominco American Incorporated in the early 1980s, chromian diopside and other kimberlitic minerals are now relatively common on the surface, and scattered around the reclaimed trench sites. At the site of the Schaffer 3 kimberlite, several megacrysts of chromian diopside were collected that were as large as 1 inch in diameter. Some pyrope-almandine megacrysts up to 5 inches in length have also been found in this area (W. Dan Hausel, personal field notes, 1979).

Mantle nodules of garnet lherzolite, garnet harzburgite, and eclogite were also recovered from these kimberlites. Some of these were as large as 10 inches in diameter. The majority of these were found on the Schaffer 3 and 15 kimberlites. The megacrysts and mantle nodules are extremely rare and make excellent museum-quality specimens.

Sloan 1 and 2 kimberlites, Colorado. These kimberlites are located in sections 10 and 15, T10N, R72W, and offer the best collecting sites for chromian diopside, even though much of the diopside is highly fractured. However, permission is required from the mineral and surface estate owners.

Kimberlite, which was initially identified in the Colorado-Wyoming region by M.E. McCallum in 1964 (McCallum and Mabarak, 1976), crops out near the western margin of the Sloan 1 intrusive. The Sloan 2 kimberlite lies near the western edge of the Sloan 1. Kimberlitic indicator minerals including chromian diopside are abundant on the surface of both intrusives as well as in nearby Rabbit Creek, primarily from past mining operations (Hausel, 1996a).

One chromian diopside collected from the Sloan property was faceted into a gem (Pete Modreski and Jack Murphy, personal communication, 1997). Several samples of kimberlite containing chromian diopside and pyrope garnet megacrysts up to 2 inches in diameter have been found on the property (**Figure 27, Plate 3**). In addition, a rare collectors item of diamondiferous eclogite, with an average grade of 21,000 carats/tonne (metric ton), was found on the property.

CORDIERITE (IOLITE)

Cordierite is an alumino-silicate often found in the vicinity of other alumino-silicates such as andalusite, kyanite, and sillimanite in alumina-rich mica schists known as metapelites (see **ANDALUSITE, KYANITE, SILLIMANITE, STAUROLITE**). In Wyoming, cordierite has been reported in the Laramie anorthosite complex and the Elmers Rock greenstone belt in the Laramie Mountains of southeastern Wyoming and at South Pass in the Wind River Range (Hausel, 1991a). It has also been reported at Copper Mountain in the Owl Creek Mountains (Hausel, Graff, and Albert, 1985).

and in the Seminoe Mountains (Hausel, 1994b).

Cordierite [$(Mg, Fe^{3+})_2 Al_4Si_5O_{18}$] is an orthorhombic mineral that typically forms short prismatic pseudohexagonal crystals with rectangular cross sections, as well as massive, compact, mineral grains of various shades of blue, bluish-violet, gray, or brown. According to Sinkankas (1964), repeated twining on $m\{110\}$ produces cordierite crystals of nearly hexagonal cross section. Cordierite exhibits poorly developed cleavage, but parting parallel to $m\{001\}$ may occur in some altered crystals.

Most cordierite in Wyoming occurs as poor-quality opaque to translucent, white-gray to brown porphyroblasts in mica schist. When found as a gemstone, the mineral occurs as translucent to transparent cordierite known to gemologists as *iolite*, or *dichroite.* Iolite was first identified in eastern Wyoming by Hausel (1998b) in the Palmer Canyon area of the Laramie Mountains west of Wheatland.

Iolite has an oily to vitreous luster and is sapphire-blue in color with marked pleochroism that changes from sapphire-blue to violet-blue, depending on which direction the mineral is viewed from. Pleochroism is the result of different wavelengths of light being absorbed in different crystallographic directions. Uniaxial minerals such as iolite, which exhibit pronounced dichroism from two pleochroic colors, are said to be dichroic, from which the gemologist term dichroite is derived.

Cordierite is found in pelitic schists (biotite and muscovite schists), and often occurs with, or as replacements of, other alumino-silicate minerals such as andalusite, sillimanite, and/or kyanite. When unaltered, cordierite has a hardness of 7 and relatively low specific gravity which ranges from 2.55 to 2.75 (the specific gravity increases with increasing iron content). Sinkankas (1964) reported that the specific gravity for transparent gem-quality cordierite lies within the range of 2.57 to 2.61.

Laramie Mountains

Anorthosite complex

The Laramie Anorthosite complex in the central Laramie Mountains contains some cordierite occurrences. Two areas are described below. *Recommended map: U.S. Geological Survey topographic map of the Laramie 1:100,000-scale Quadrangle.*

Section 20, T17N, R71W. One of the largest occurrences of cordierite is on a ridge 300 feet above the surrounding topography. Cordierite at this site is localized near the center of a fold and is reportedly all industrial grade (Newhouse and Hagner, 1949).

Sections 17, 18, 19, and 20, T17N, R71W and sections 13, 14, and 24, T17N, R72W. Small grains of cordierite are found in noritic anorthosites a short distance north of the Rogers Canyon road and west of Ragged Top Mountain in the vicinity of Lake Hills, northeast of Laramie. Anorthosite, noritic anorthosite, and metanorite are present in the northern part of the area and are succeeded southward by these gneiss zones: syenite-diorite gneiss, a mixed zone of interlayered metanorite and gneisses, diorite gneiss, porphyroblastic granodiorite gneiss, and quartz monzonite gneiss.

The cordierite-bearing metanorite is gray, fine-to medium-grained rock and consists mainly of cordierite with hyperstene, andesine, biotite, microcline, and quartz, with minor amounts of magnetite-ilmenite, apatite, spinel, and garnet. The weathered cordierite surfaces are dark brown; freshly fractured surfaces are blue to bluish-gray (Howard, 1955).

According to Subbarayuda (1975), the cordierite occurs in lenticular layers and lenses a few inches long and wide to 240 feet long and 30 feet wide, and may form as much as 50 to 80% of the norite host rock. Subbarayuda (1975) interpreted the cordierite in cordierite-hypersthene gneiss to be the result of contact metamorphism of sedimentary rock precursors.

Palmer Canyon region

The Palmer Canyon region west of Wheatland and areas both north and south of Palmer Canyon, contain metapelites with a variety of porphyroblasts. Some porphyroblasts reported in this region include alumino-silicates associated with metapelites (see **ANDALUSITE, KYANITE, SILLIMANITE, STAUROLITE**), gem-quality cordierite, and low-grade rubies and sapphires (see **CORUNDUM**). *Recommended map: U.S. Geological Survey topographic map of the Laramie Peak 1:100,000-scale Quadrangle.*

Owen Creek area. This occurrence is in sections 9 and 10, T25N, R71W, about 7 miles north of Palmer Canyon. Cordierite was found with kyanite, sillimanite, and some relict staurolite crystals (Snyder and others, 1995).

Palmer Canyon. The Palmer Canyon prospect (also known as the Roff vermiculite prospect) is located in N/2 section 18, T24N, R70W, north of the Palmer Canyon road (**Figure 5**) about 17 miles west of Wheatland. The Palmer Canyon road originates in Wheatland and is paved much of the distance to the prospect. At this prospect, mica schists and gneisses contain vermiculite, kyanite, sillimanite, corundum, transparent cordierite, and biotite.

The Palmer Canyon prospect lies within a gneiss complex northeast of Elmers Rock greenstone belt, and should be of interest not only to mineral collectors, but also to metamorphic petrologists, as the pelitic gneisses and schists in this region contain a variety of porphyroblasts. For example, the Grizzly Creek prospect (**Figure 5**) (see **ANDALUSITE, KYANITE, SILLIMANITE, STAUROLITE**) located southwest of the Palmer Canyon deposit is reportedly underlain by schists with abundant kyanite and sillimanite. The Palmer Canyon deposit not only contains cordierite, but also has some sillimanite, kyanite, staurolite, and pink and white corundum.

During field investigations, iolite (cordierite) was discovered by Hausel (1998b) along strike and immediately east of the Roff vermiculite prospect pit. The iolite occurs as porphyroblasts in a gray cordierite-biotite gneiss. The mineral is transparent, sapphire-blue to violet-blue with good pleochroism (**Figure 28, Plate 3**). Samples of the gneiss may contain from a trace to as much as 15 or 20% cordierite. A large (1.25-inch maximum length) iolite specimen collected by the senior author was found within a distinct 2.5- by 1.5-inch depression in the gneiss which marked the former presence of a much larger iolite crystal.

Samples of iolite collected by the senior author do not appear to be seriously flawed and include some high-quality transparent material of a few carats in weight. However, the presence of partings, as well as some fractures, tends to reduce the size of material that can be cut. Additionally, the amount of material found on the surface in the immediate vicinity of the Roff vermiculite prospect may be fairly limited. However, detailed mapping in the area along with exploration at shallow depths and sampling of alluvium downslope, could lead to the discovery of additional gemstones. Much of the surface of the deposit has been thoroughly picked over by collectors since the recent discovery of the gemstone (W. Dan Hausel, personal field notes, 1996). *Recommended map: U.S. Geological Survey topographic map of the Reese Mountain 1:24,000-scale Quadrangle.*

Wind River Range

The Wind River Range in western Wyoming hosts several interesting minerals and rocks. The most notable area lies in the southern part of the range in the South Pass and Anderson Ridge areas south of Lander (**Figure 3**). This area is noted for gold, but also has some corundum, serpentinite, beryl, tourmaline, banded iron formation, arsenopyrite, scheelite, spotted basalt, and other interesting rocks and minerals. Hausel (1984), Snyder and others (1989), Hausel and Hull (1990), and Hausel and Love (1992) published field guides to this region that we recommend to the interested collector. The guides provide invaluable insight and some collecting locations. *Recommended maps: U.S. Geological Survey topographic maps of the South*

Pass and Lander 1:100,000-scale quadrangles.

Rose mine. Located in SE section 2, T29N, R100W, this mine is accessible from a jeep trail near the Atlantic City BLM campground and is located within one mile of a graded road that serves Atlantic City (Hausel, 1984).

In the search for gold, the Rose shaft was sunk on a near-vertical, 2- to 3-foot-wide, N60°E-trending shear zone in metagreywacke schist of the Miners Delight Formation (Archean) (Hausel, 1989). The schist in the near vicinity of the mine is fairly aluminum-rich, as is evident by common mica. The relatively high metamorphic grade (due to deep burial of the sediments in this area) produced abundant, gray to brown, almond-shaped porphyroblasts that crystallized in the plane of rock foliation. The unique texture of the rocks in this area has led to the name *peanut schist*, which is used by many of the local residents and rock hounds. The *peanuts*, or porphyroblasts, resemble andalusite and are almost entirely replaced by sericite, biotite, and quartz. However, x-ray diffraction studies of the crystals yielded patterns still characteristic of the original cordierite (Hausel, 1991a). The cordierite is opaque.

CORUNDUM (RUBY and SAPPHIRE)

Corundum is second only to diamond in hardness: on Moh's hardness scale, corundum has a hardness of 9 compared to diamond's hardness of 10, diamond being the hardest known natural substance on Earth. Because of its extreme hardness, transparent to translucent colored varieties of corundum are highly prized gemstones.

Opaque varieties of corundum are much more common than gemstone corundum and are used primarily in industry. Industrial corundum comes in a variety of colors and is used primarily for grinding. Emery, one industrial variety of corundum, is typically black to gray and is used as a grinding agent on emery wheels. The color of emery is the result of an intermixture of corundum with magnetite or hematite, and less commonly with hercynite (iron spinel) (Dana and Ford, 1932).

Gemstone varieties of corundum include ruby and sapphire, both of which are found in Wyoming. Other than diamond and hyacinth (zircon), no other stone has such brilliant and perfect luster and such marked fire as ruby and sapphire (Bauer, 1968b).

The luster of corundum is adamantine to vitreous. Since many gemstone corundums have been found and mined in the Orient, the suffix *oriental* has been attached to the different colored gems in the past. However, this archaic terminology has caused considerable confusion. Hurlbut and Switzer (1979) recommended that this terminology be discontinued and replaced by modern descriptive terms (**Table 2**). For example, red gem-quality corundum known as oriental ruby should just be identified as ruby. All other colored corundum gemstones are called sapphire with a prefix to note the color of the sapphire. The exception to this is blue sapphire, which should simply be called sapphire.

The most desirable color of ruby is dark purplish-red, known as *pigeon's blood red*. The most desirable color for sapphire is velvety cornflower blue

Table 2. Gemstone varieties of corundum (from Hurlbut and Switzer, 1979).

Gemstone color	Archaic terminology	Modern terminology
Red	Oriental ruby	Ruby
Blue	Oriental sapphire	Sapphire
Colorless	Leuco-sapphire	White sapphire
Light bluish-green	Oriental aquamarine	Bluish-green sapphire
Green	Oriental emerald	Green sapphire
Yellowish-green	Oriental chrysolite	Yellowish-green sapphire
Yellow	Oriental topaz	Yellow sapphire
Aurora-red	Oriental hyacinth	Aurora-red sapphire

called *Kashmir blue*. Both ruby and sapphire are aluminum oxides that differ only in color, which is the result of the type and the amount of impurities in the mineral (Hurlbut and Switzer, 1979). The amount of impurities is generally very small in gemstones, but can be as much as 10% in some industrial corundum, rendering them cloudy and resulting in the loss of any aesthetic value as a gemstone (Bauer, 1968b).

Rubies are colored by a small amount of chromium (up to 4%) which replaces aluminum in the crystal lattice. A small amount of iron along with the chromium imparts a reddish-brown color. The chromium in the ruby, according to Hurlbut and Switzer (1979), will cause the mineral to strongly fluoresce red under long- and short-wavelength ultraviolet light. However, the purplish-red corundum and rubies from the Tin Cup district in central Wyoming do not fluoresce, even though these are thought to contain some chromium. The blue color in sapphire is due to the presence of small amounts of iron and titanium.

The crystal habit of corundum is a six-sided (hexagonal) prismatic crystal that is frequently barrel-shaped (Vanders and Kerr, 1967). Well-formed corundum may occur as tabular, prismatic, or pyramidal crystals with tapering hexagonal pyramids (**Figure 29, Plate 3**) (Hurlbut and Switzer, 1979), terminated by basal planes perpendicular to the prisms. The basal terminations typically have regular, triangular striations (Bauer, 1968b). Corundum does not have cleavage but exhibits a basal and rhombohedral parting.

Some rubies and sapphires exhibit *asterism*. Such stones are known as star rubies or star sapphires, and exhibit a six-rayed star caused by light reflectance from oriented, needle-like mineral inclusions of rutile within the gemstone (Hurlbut and Switzer, 1979). The needle-like crystals lie in planes perpendicular to the c-axis of the corundum.

Corundum has a relatively high specific gravity (3.94 to 4.08) (Bauer, 1968b). Because of the weight of the mineral, detrital corundum is often found in placer deposits downstream from its host rock, and may be found along with other minerals with high specific gravity such as gold, magnetite, and garnet.

Large rubies are rare. The largest ruby reported was found in Tibet and weighed 2000 carats, but was not perfectly transparent. Another large, semi-precious corundum weighed 1184 carats. Bauer (1968b) also reported other large rubies including stones the size of a small hen's egg and the size of a pigeon's egg. One industrial grade corundum recently found in the Tin Cup district of Wyoming was the size of a hen's egg and measured 2 inches long (W. Dan Hausel, personal field notes, 1995). If this particular stone were of gem-quality, it would rank with the largest rubies found in the world. Larger stones will probably be found in the district.

Corundum is often found as an accessory mineral in some metamorphic rocks such as mica schist, gneiss, and crystalline limestone. It has also been found in some silica-poor igneous rocks such as syenites, nepheline syenites (Hurlbut, 1966), serpentinites, and some lamprophyres. Gem corundum is typically found as a secondary mineral in some contact metamorphic deposits formed between limestone and some igneous rocks (Bauer, 1968b).

The best known ruby locality in the world is the Mogok, Myanmar (Burma) deposit, where the gemstones occur in soil eroded from metamorphosed limestone. Rubies found in Thailand occur near Bangkok in clay derived from the decomposition of a basalt. The finest sapphires come from the Zanskar district of Kashmir. High quality sapphires are also found in central Queensland, Australia, and near Inverell, New South Wales, Australia.

In the United States, gemstone corundum has been reported at several sites. These include Franklin, North Carolina, and the Lauel Creek mine, Georgia (Hurlbut and Switzer, 1979). Other localities which have produced corundum include Newton, Franklin, and Sparta counties, New

Jersey. According to Sinkankas (1959), occasional pockets of transparent, gem-quality, bluish-gray sapphire and ruby were intersected during quarrying operations in those areas. The pockets appeared to be confined along a contact of metamorphosed limestone.

Corundum deposits have also been encountered in a belt of peridotitic rocks extending from the Gaspé Peninsula in Canada to Tallapoosa County, Alabama. Some doubly-terminated, barrel-shaped, gem-quality crystals or nodules of sapphire and corundum have been recovered from deposits in Jackson, Macon, and Clay counties in North Carolina (Sinkankas, 1959). The gems include ruby and pink, yellow, green, and blue sapphire. One sapphire crystal from Macon County weighed 312 pounds and exhibited several, small, clear, areas of deep blue color. This was undoubtedly one of the largest sapphires found in the world.

Sapphires and other forms of corundum appear to be widespread in Montana. Sapphires up to 0.5 inch in diameter have been mined from Montana intermittently since the late 1800s (Voynick, 1987a, 1987b). High-quality gem sapphires are found in a lamprophyre dike and in associated placers at Yogo Gulch, Montana (Hurlbut and Switzer, 1979). Gem-quality sapphires have been recovered from the Missouri River northeast of Helena, and a considerable amount of corundum with some gem sapphires were mined from Rock Creek southwest of Phillipsburg. Corundum (including gems) has also been recovered from Pole Creek (which drains into the Madison River), along Clark Creek, and in Quartz Gulch (Sinkankas, 1959).

Within Wyoming, corundum has been reported in the Granite Mountains of central Wyoming, Green Mountain, the Laramie Mountains, Medicine Bow Mountains, Seminoe Mountains, Wind River Range, and recently in the Sierra Madre.

Granite Mountains

The Granite Mountains in central Wyoming provide one of the better areas to explore and prospect for gemstones, semi-precious stones, and lapidary materials in Wyoming. Gemstones and other minerals found in the Granite Mountains include rubies, sapphires, jade, spodumene, jasper, and agate. Diamonds were also reportedly found in this region (Gene Clark, personal communication, 1985), but were never verified (Malcom E. McCallum, personal communication, 1985).

There are reports that gem-quality rubies and sapphires may exist in this region. One report described deep red to purplish-red rubies somewhere near the Sweetwater Divide. Some specimens collected from the outcrop were cut and polished in Denver, producing star-rubies. According to Curtis (1943), these would have made "exceptionally fine gemstones... had they been without flaws and cracks." Specimens up to one inch were found. According to Osterwald and others (1966), the samples were found in mica schist and serpentinite [this may be the Red Dwarf corundum deposit].

Rubies have also been reported in the Barlow Gap region in the north-eastern part of the Granite Mountains (Larry Clark, personal communication, 1995), and some specimens of ruby spinel were found in mafic micaceous schist float rock in the vicinity of the Red Dwarf ruby deposit. The spinels had excellent color, were translucent to opaque, and averaged 0.12 inch across. The source of the spinel was not found (Ralph Platt, personal communication to Hausel, 1999). *Recommended maps: U.S. Geological Survey topographic maps of the Baroil, Rattlesnake Hills, and Lander 1:100,000-scale quadrangles.*

Beaver Rim area (see also **JADE**)

There are two described occurrences in this area. *Recommended map: U.S. Geological Survey topographic map of the Rattlesnake Hills 1:100,000-scale Quadrangle.*

Muskrat Creek. This occurrence is in section 20, T32N, R91W. According to Love (1970), soft green mica schist boulders with dark-red rubies were found near Muskrat Creek in the Wind River Formation (Eocene) near Beaver Rim, west of the Gas Hills uranium district. The rubies were up to 1 inch in diameter and highly fractured. The source of the schist is unknown, but presumably lies to the south in the Granite Mountains.

T32N, R91W. A placer deposit containing abundant, bright red (>1 inch in diameter) fractured rubies was reported by Osterwald and others (1966).

Sweetwater Station area (see also **JADE**)

Two occurrences in this area are described below. *Recommended map: U.S. Geological Survey topographic map of the Lander 1:100,000-scale Quadrangle.*

Abernathy deposit. Located near Sweetwater Station in section 26, T30N, R96W. Pale-blue and white sapphires occur in mica schist enclosed by gray-brown granite. The sapphires are abundant and form 1-inch diameter nodules in the schist. For the most part, these are badly shattered and altered around the edges (Hagner, 1942a; Love, 1970). The rocks occur about 4 miles west of Sweetwater Station in the vicinity of Rocky Draw. Gray jade is found nearby in aplite (Love, 1970).

Marion claim. Pale to bright-red rubies are found in mica schist north of the Abernathy deposit in T31N, R96W. Some of the specimens were cut into gems (Osterwald and others, 1966).

Tin Cup district (see also JADE and JASPER)

Red Dwarf. This area lies along the southern margin of the Tin Cup district, western Granite Mountains, in sections 13 and 24, T30N, R93W (**Figure 30**). The area is accessible from Jeffrey City by driving 4 miles west along U.S. Highway 287 to the Graham Ranch road turnoff. Another access route lies 3 miles north of Jeffrey City along the Gas Hills road. At this junction, the access route turns west onto a jeep trail near the reclaimed Western Nuclear uranium mill site. *Recommended maps: U.S. Geological Survey topographic maps of the Tin Cup Mountain, Graham Ranch, Muskrat Basin, and Stampede Meadow 1:24,000-scale quadrangles.*

Hausel (1996d) mapped a corundum gneiss with more than 4000 feet of strike length and widths varying from 20 to 50 feet (**Figure 31**). The gneiss grades from a gray quartzofeldspathic gneiss along its northern extent to a chloritic schist and gneiss to the south. The gneiss is principally a biotite-quartz-feldspar gneiss containing 1 to 10% ruby and corundum porphyroblasts partially replaced by fuchsitic reaction rims, as well as fuchsite pseudomorphs after ruby (**Figure 32, Plate 4**). To the south, the gneiss grades into a chlorite schist and gneiss containing abundant chlorite, minor biotite, quartz, and accessory corundum and ruby. The amount of corundum and ruby appears to decrease in the chloritic schist to the south, as only about 10 to 20% of the porphyroblasts in the chlorite schist appear to have corundum preserved within the reaction rims.

Where the corundum is preserved, it is typically encased in a fuchsitic reaction rim, providing evidence that the corundum was out of equilibrium. This resulted in partial to complete replacement by very fine-grained chrome-mica during a retrograde metamorphism. Where preserved, the corundum ranges from light purplish-pink to lavender to reddish-purple, and occurs as prismatic, hexagonal grains from one millimeter to 2 inches in diameter (Hausel, 1996d). Some of the stones are gem to near-gem quality (Love, 1970; Robert Odell, personal communication, 1998).

Microscopic examination shows most of the corundum to be translucent. A few rubies collected from this area were cut into cabochons and a few produced good asterism, but most of the material has been fractured and is of poor quality (George DeVault, personal communication, 1988). A few other stones were recently cut and polished into cabochons, and were reportedly of high value (Robert Odell, personal communication, 1998).

In addition to the corundum gneiss at Red Dwarf, a massive serpentinite to the west contains very small (millimeter size), light-blue, translucent to opaque corundum (Robert Odell, personal communication, 1995). These

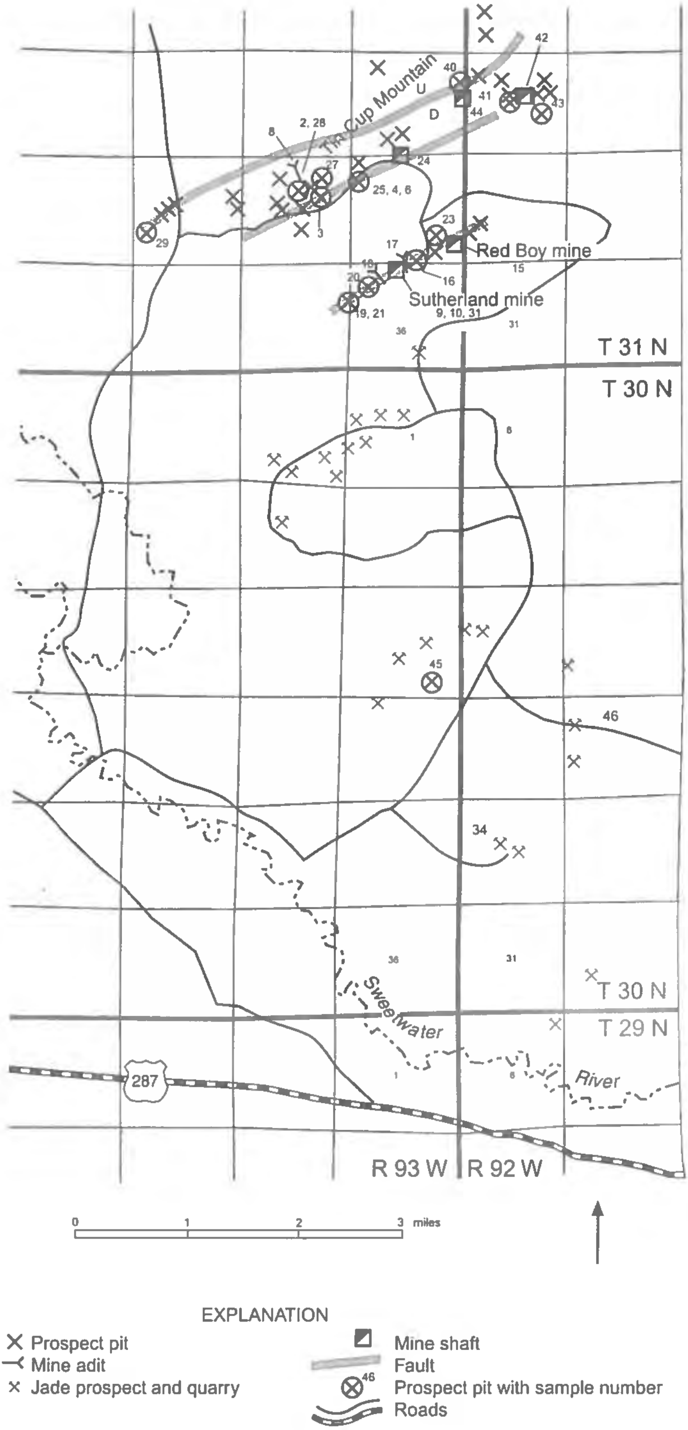


Figure 30. Map of the Tin Cup district in the Granite Mountains showing corundum, jade, pyrite, agate, and jasper localities (from Hausel, 1996d). Mine adits, mine shafts, and jade prospects and quarries are numbered where sampled.

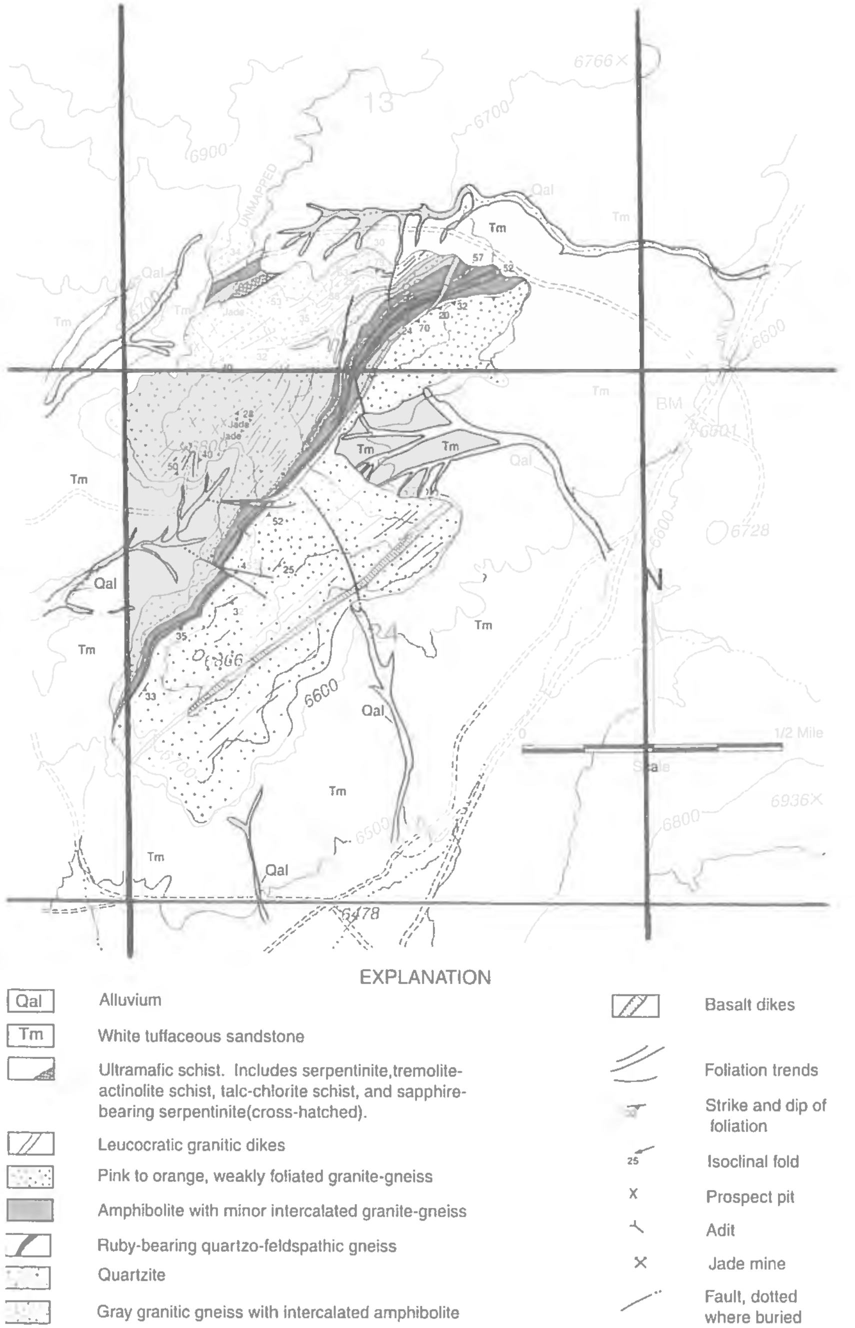


Figure 31. Geologic map of the Red Dwarf ruby gneiss, T30N, R93W, Tin Cup district, Wyoming. Geology has been generalized and base map/topography simplified from Hausel, 1997b.

tiny sapphires were confirmed as corundum by XRD analysis (Robert W. Gregory, written communication, 1995). Locally, the serpentinite contains as much as 20 to 40% corundum (W. Dan Hausel, personal field notes, 1995).

Sections 23 and 26, T31N, R92W. Rubies were reported 5 to 6 miles northeast of the Red Dwarf ruby deposit (J. David Love, personal communication, 1989). No specific details on this occurrence were given.

Green Mountain

Green Mountain is located south of the Granite Mountains in central Wyoming. The Green Mountain area is accessible from Jeffrey City by roads leading south from U.S. Highway 287/State Highway 789. The Green Mountain area encloses the Green Mountain-Crooks Gap uranium mining district which is underlain by Archean granitic and gneissic rocks that are onlapped by Paleozoic, Mesozoic, and Tertiary sedimentary rocks. Much of Green Mountain is covered by the Oligocene(?) Crooks Gap Conglomerate which consists of giant granite boulders in an arkosic matrix (Love and Christiansen, 1985).

Green Mountain. Ruby-bearing chloritic schist float, similar to the ruby schist from the Red Dwarf area, was found along the northern flank of Green Mountain (section 14, T28N, R91W) by Avon Brock, a prospector from Saratoga, Wyoming. The rock was a cobble derived from the Crooks Gap Conglomerate, and contained several deep red rubies up to an inch across (Hausel, 1986b). The original source of the schist is unknown.

Laramie Mountains

Corundum has been identified in a vermiculite schist west of Wheatland in the Palmer Canyon area (see **ANDALUSITE, KYANITE, SILLIMANITE, STAUROLITE;** and **CORDIERITE**) and in granite northwest of Palmer Canyon. Microscopic sapphires and rubies have been recovered from stream sediment samples in the Laramie Mountains (see Hausel and others, 1988b). Other significant heavy minerals such as gold, scheelite, fluorite, and monazite were also recovered from a few of these samples. *Recommended map: U.S. Geological Survey topographic map of the Laramie Peak 1:100,000-scale Quadrangle.*

Elk Park. Purple corundum, up to 0.75 inch in diameter and 4 inches in length, was reported in a xenolith in granite a few miles northwest of Palmer Canyon in the Elk Park area (NW section 15, T26N, R71W) (**Figure 14**) (Ray

E. Harris, personal communication, 1992). *Recommended map: U.S. Geological Survey topographic map of the Fletcher Park 1:24,000-scale Quadrangle.*

Palmer Canyon. This is located in the N/2 section 18, T24N, R70W. Both red translucent ruby and white to pink, translucent to opaque sapphire occur in vermiculite schist on the Roff prospect in Palmer Canyon about 17 miles west of Wheatland (**Figures 5** and **6**). The schist is associated with kyanite, cordierite, staurolite, and sillimanite schist and gneiss.

The corundum occurs as small hexagonal pink, red, purplish-red, and white mineral grains typically about 0.1 to 0.25 inch across. Many of the grains are fractured and have well-developed cleavage with minor mineral inclusions. A few specimens collected from the property have excellent color, are transparent, and could possibly be cut into gemstones (W. Dan Hausel, personal field notes, 1997). Unfortunately, much of the material collected from the deposit has poor color (light pink) and is translucent.

Locally, the schist at this site may contain as much as 20 to 30% corundum. Because the corundum occurs in vermiculite, it can be easily extracted since the schist readily crumbles. *Recommended map: U.S. Geological Survey of the Reese Mountain 1:24,000-scale Quadrangle.*

Stream sediment samples

Panned sample concentrates collected during the exploration for kimberlite and diamonds in the 1980s, produced some small sapphires and rubies in drainages in the central Laramie Mountains (Hausel and others, 1988). These tiny minerals have no value, but suggest the presence of several nearby, undiscovered corundum schists. The samples included:

NW NE section 20, T14N, R71W. A ruby was recovered from Crow Creek.

SW section 29, T19N, R71W. One ruby was recovered from sediments in a main eastward-flowing drainage.

SW SE section 7, T22N, R72W. One dark blue sapphire was recovered from an unnamed drainage.

NW NE section 12, T22N, R73W. One blue sapphire was recovered from a drainage in this area.

NW NW section 13, T22N, R73W. A blue sapphire was recovered from a drainage in this area.

NW SW section 29, T23N, R72W. A tiny blue sapphire was recovered from a drainage entering the Laramie River from the north.

SW NE section 34, T23N, R73W. Three blue sapphires were recovered from a drainage entering the Laramie River from the east.

Medicine Bow Mountains-Saratoga Valley

There are three areas where corundum is reported in this part of Wyoming. *Recommended map: U.S. Geological Survey topographic map of the Saratoga 1:100,000-scale Quadrangle.*

Baggot Rocks. In the area of Baggot Rocks, section 15, T15N, R83W (**Figures 7** and 8), tiny specks of corundum are associated with kyanite and vermiculite in biotite- and hornblende-schist (Osterwald and others, 1966). The deposit was prospected and mined from 1937 to 1941 for vermiculite, and shafts and prospect pits were dug along contacts between hornblende schist and granite pegmatite (Hagner, 1944) (also see **BERYL**).

Homestead Draw area. This occurrence is located in E/2 NE section 34, T14N, R82W. An open cut mine developed on vermiculite in a granite-gneiss contained scattered pockets of ruby. Some of these rubies contain reaction rims of fuchsite similar to the Red Dwarf ruby deposit in the Granite Mountains (Ralph Platt, personal communication to Hausel, 1999). *Recommended map: U.S. Geological Survey topographic map of the Barcus Peak 1:24,000-scale Quadrangle.*

Summit Reservoir area. This occurrence is located in NE NW section 3, T13N, R82W, southwest of the Homestead Draw deposit. As at Homestead Draw, pockets of ruby found in vermiculite occur in granite-gneiss in an open cut mine also located on the Barcus Peak 1:24,000-scale Quadrangle map. The rubies are closely associated with the vermiculite, and vermiculite is scattered over a large semi-circular area between Homestead Draw and Summit Reservoir northwest of Coyote Hill (Ralph Platt, personal communication to Hausel, 1999). Thus, the extent of the ruby mineralization in this area could be much larger than is presently known.

Seminoe Mountains

North Platte River. A specimen of corundum was reported from the eastern Seminoe Mountains near the North Platte River, and a ruby was reported from limestone in the southeastern Seminoe Mountains (Aughey, 1886). [Authors' note: Since no skarns are known in this area, the ruby-limestone association is highly unlikely.]

Wind River Range

Big Sandy River. Abundant industrial corundum with some rubies, including star rubies, have been found in the drainage of the Big Sandy River in the southern Wind River Range (Spendlove, 1989). The source of the placer rubies has not been found, but based on the abundance of material in the drainage, the source rock in all probability lies a short distance upstream from the placers.

DIAMOND

Natural diamonds occur in two different crystal systems, isometric and hexagonal. Terrestrial diamonds are isometric; hexagonal diamonds (lonsdalite) are extremely rare and restricted to some meteorites and associated impactites. Only isometric diamonds will be described here.

In its simplest form, isometric diamond is an equal-dimensional mineral with six-sided cubes referred to as hexahedrons. However, the most common habit of diamond is the octahedron. Octahedrons form 8-sided bipyramids, although some octahedrons may develop ridges on the octahedral faces resulting in crystals of trisoctahedral and hexoctahedral habit. Partial resorption of octahedral diamonds can produce rounded dodecahedrons (12-sided) with rhombic faces. Many dodecahedrons develop ridges on the rhombic faces resulting in a 24-sided crystal known as a trishexahedron. Four-sided tetrahedral diamonds are sometimes encountered, and these are probably distorted octahedrons. Another relatively common form of diamond is the *macle*, or twinned diamond. Many macles form flattened triangular crystals.

The surface of diamond may contain growth trigons, and less commonly pits, which may further distort the habit of the crystal, resulting in many different habits. Further details can be obtained from Bauer (1968a) and Bruton (1978).

Diamonds have a brilliant greasy luster that is likened to oiled glass. Gem-quality diamonds can occur as translucent to transparent, colorless, green, yellow, brown, and rarely blue or pink stones. Opaque and heavily included diamonds are used for industrial purposes.

Diamond is brittle, extremely hard (H=10), has a specific gravity of 3.5, and perfect octahedral cleavage. Even though diamond is heavier than water, it is non-wettable (hydrophobic) and will float on water under favorable circumstances. Diamonds are also grease attractive and will stick to grease. Under ultraviolet light, many diamonds fluoresce pale blue, green-yellow, and rarely red.

Since diamonds are extremely rare, it takes considerable effort and patience to find them. It has been estimated that diamond occurs in concentrations of less than one part per million, even in commercial deposits of diamondiferous kimberlite and lamproite. As described below, diamonds have been found and/or reported at several locations in Wyoming. The reader is also referred to Hausel (1998d) for a more complete discussion of diamond properties, origin, and occurrences in Wyoming and the U.S.

Granite Mountains

Diamond Springs. Four diamonds were reportedly found in the Diamond Springs Draw area of the Granite Mountains several years ago (Gene Clark, personal communication, 1980). However, this occurrence has not been verified. *Recommended map: U.S. Geological Survey topographic map of the Rattlesnake Hills 1:100,000-scale Quadrangle.*

Greater Green River Basin

Reports suggesting that diamonds have been found in the Greater Green River Basin have attracted interest in recent years. The source of some of the diamonds is reportedly a group of mantle-derived pipes near Cedar Mountain. Along with the pipes, extensive kimberlitic indicator mineral anomalies (**Figures 22** and **23, Plate 2**) are scattered over a 500- to 1000-mi^2 region in the basin extending south into the Uinta Mountains, and as far north as Interstate 80 (**Figure 21**) (McCandless and others, 1995). Other rocks of interest include the Leucite Hills north of Rock Springs (**Figure 21**), where a group of 22 known lamproites have been mapped and identified (Ogden, 1979), although no diamonds have been reported in that area to date (see **PERIDOT** and **RARE AND UNUSUAL ROCKS**). *Recommended maps: U.S. Geological Survey topographic maps of the Firehole Canyon and Evanston 1:100,000-scale quadrangles.*

Butcherknife Draw. Four diamonds were reportedly found in the Butcherknife Draw area (Ts15 and 16N, R112W) north of Cedar Mountain (Paul and Jean Miller, personal communication, 1994). One diamond(?), currently owned by a Green River resident, was cut in Germany and mounted in a ring (**Figure 33, Plate 4**). The stone measured 0.3 inch across and was apparently confirmed as diamond by a gemologist using a GEM® diamond tester (Hausel, Sutherland, and Gregory, 1995).

Cedar Mountain. Ten cryptovolcanic breccia pipes are found along the southwestern flank of Cedar Mountain near Lonetree, a short distance north of the Utah border (Richard E. Kucera, personal communication, 1996). The pipes lie along a 5- to 10-mile-long, north-south-trending lineament in the Bridger Formation (Eocene). Another two pipes were found in the same area in late 1997.

According to Guardian Resources, two diamonds were recovered from a drill-core sample at one of the pipes known as the DK pipe. A third diamond was recovered from a sample concentrate collected north of the DK pipe. This diamond was reported to have a maximum diameter of 2.2 mm with SI clarity and J color. The diamonds recovered from the core had maximum diameters of 1.07 mm and 0.13 mm, respectively.

In addition to these diamonds, there have been unverified reports of other diamonds in this same area. One report indicated that a major mining company may have found five diamonds in this area in the early 1980s.

According to Guardian Resources (press release, 9/24/96), 48 other alluvial diamonds were recovered from sample concentrates collected from a new source other than the DK pipes. These diamonds were reportedly verified by Diamonds Direct in Vancouver, and weighed a total of 2.3 carats. These diamonds(?) were found north of the DK pipes at an undisclosed location, but the WSGS has not been able to verify them.

Gros Ventre Range

A 7- to 9-carat, blue-white, gem-quality diamond was reportedly found in a prospect pit in the Gros Ventre Range in northwestern Wyoming. The diamond was verified by a gemologist from Jackson (J. David Love, personal communication, 1981). The prospect pit was dug in a hard, silicified, dark metamorphosed rock.

Laramie Mountains

The Laramie Mountains of southeastern Wyoming host a number of kimberlites (also see **CHROMIAN DIOPSIDE AND CHROMIAN ENSTA-**

TITE), several of which contain diamonds. In addition, numerous kimberlitic indicator mineral anomalies have been identified in the Laramie Mountains (Hausel and others, 1988), suggesting the presence of many undiscovered kimberlite pipes and dikes.

To date, the State Line district along the Colorado-Wyoming border has been relatively productive as far as the number of diamonds recovered from kimberlite. Yet streams in this region have not been systematically explored for detrital or placer diamonds, and in all probability, thousands (if not hundreds of thousands) of diamonds lie downstream from the district. *Recommended maps: U.S. Geological Survey topographic map of the Rock River 1:100,000-scale Quadrangle; for a location map of the kimberlites, see Hausel, 1998d.*

Elmers Rock greenstone belt. One of the more impressive regions for abundant kimberlitic indicator mineral anomalies discovered by the WSGS lies within the Elmers Rock greenstone belt, which is north of Sybille Canyon. This greenstone belt may host dozens of undiscovered kimberlites. There is also an unverified report of a diamond found in the area of Blue Grass Creek (Ron W. Marrs, personal communication, 1981), although only a few garnets found in this area have been tested. Some pyrope garnets collected by the WSGS in this region are typical of diamond-stability (G10) pyropes.

Grant Creek. Samples collected in the Grant Creek drainage (section 36, T21N, R71W) northeast of Middle Sybille Creek yielded numerous pyrope garnets, some chromian diopsides, and picroilmenites (Hausel and others, 1988). Although unverified, microdiamonds have also been reported from this area. Diamond-stability pyrope garnets were recovered from nearby drainages to the east and west at Mule Creek and Middle Sybille Creek by the WSGS.

Iron Mountain district. This district is located about 45 miles north of the State Line district and a few miles south of Sybille Canyon along the eastern flank of the Laramie Mountains. It comprises part or all of sections 2, 3, 7, 8, 9, 10, 15, 16, 17, and 18, T19N, R70W. Smith (1977) mapped 57 hypabyssal-facies kimberlite occurrences in the district; Hausel remapped these occurrences in 1998 and 1999. Work by the senior author shows that these occurrences are part of an extensive dike/blow complex (**Figure 24**).

At least two of the kimberlites in the district were tested by Cominco American Incorporated in the early 1980s. Apparently, one macrodiamond was recovered during testing (Howard G. Coopersmith, personal communication, 1999). Smith (1977) collected some small grab samples, but did not recover any diamonds.

Diamond-stability kimberlitic indicator minerals have been identified in the district by the WSGS as well as by McCallum and Waldman (1991). G10 (diamond inclusion) peridotitic pyrope garnets, and Group I (diamond inclusion) eclogitic pyrope-almandine garnets have been recovered from some of the Iron Mountain intrusives. The chemistry of these garnets indicates some of the Iron Mountain kimberlites originated within the diamond-stability field of the upper mantle and should contain some diamonds and possible low-grade diamond resources.

LaPrele Dam area. A small diamondiferous kimberlite was reportedly found in the LaPrele dam area southwest of Douglas on LaPrele Creek in the northern Laramie Mountains (Bob Berry, Exolite Corporation, personal communication to Sutherland, 1988). It was reported that blue ground from this occurrence was panned, yielding several rounded crystals that produced octahedral cleavage when broken. However, this report is unverified.

State Line district

The State Line district is underlain by Proterozoic schists and granites of the Colorado Province. The district extends 5 miles north into Wyoming and 12 miles south into Colorado and encloses approximately 40 known kimberlites, of which most (if not all) are diamondiferous (**Figure 26**). The exposed Precambrian crystalline rocks in this region consist of 1.9- to 1.7-Ga metamorphic rocks that are disconcordantly intruded by 1.4-Ga granitic rocks of the Sherman and Log Cabin batholiths. The Log Cabin Granite locally intrudes the Sherman Granite. *Recommended maps: (1) Hausel and others, 1981, pl. 1; (2) Hausel and others, 1997, various figures; and (3) U.S. Geological Survey topographic maps of the Ft. Collins and Laramie 1:100,000-scale quadrangles.*

Access to most of the kimberlite intrusives has been somewhat difficult due to private lands surrounding federal and state lands. *Recommended maps: BLM surface and mineral management status maps of the Fort Collins, Colorado and the Laramie, Wyoming 1:100,000-scale quadrangles.*

The only post-Precambrian rocks found in the vicinity of the State Line district are arkosic sedimentary rocks of the Pennsylvanian Fountain Formation located along the margin of the district and rare Cambrian, Ordovician, and Silurian sedimentary xenoliths found in some kimberlite diatremes (McCallum and others, 1979).

Both hypabyssal and diatreme facies kimberlite (see Hausel, 1998d for discussion of these and related terms) occur in the district, with only minor fragments of crater facies kimberlite reported in the Kelsey Lake intrusives. Diatreme facies kimberlite contains abundant subrounded to angular rock fragments with serpentinized macrocrysts of olivine and lesser enstatite, chrome-rich and chrome-poor pyrope garnet, diopside, picroilmenite, clinopyroxene-ilmenite intergrowths, and phlogopite. These occur in a finely crystalline matrix dominated by serpentine with lesser carbonate, olivine, diopside, picroilmenite, phlogopite, perovskite, magnetite, chrome-rich spinel, hematite, apatite, and zircon (Rogers, 1985; McCallum, 1991).

The hypabyssal facies kimberlite is a massive porphyry found in dikes, sills, and small plug-like bodies that represent root zones (*blows*) of deeply eroded pipes. The mineralogy of hypabyssal kimberlite is essentially the same as diatreme facies; however, globular, emulsion-like segregations of serpentine and calcite are more abundant in the hypabyssal facies (Rogers, 1985). In addition, xenolithic fragments rarely exceed a few percent of the hypabyssal facies (unlike the diatreme facies), and where present, are typically well-rounded upper mantle and lower crustal nodules.

The kimberlites in the State Line district are generally poorly exposed, have negligible relief, and are deeply weathered. Erosional models suggest that many of the kimberlites may have been deeply eroded with as much as 50% of the original pipes having been removed through time (McCallum and Mabarak, 1976). Thus, a significant potential for placer diamonds may occur downstream from the kimberlites; in fact, some recreational prospectors have reported finding diamonds along with gold in the Poudre River and some tributaries in Colorado. However, most drainages in the district have not been prospected for diamonds.

Many of the kimberlites are covered by colluvium and/or alluvium; these hidden kimberlites are generally recognized by the presence of gray, weathered, blue-ground kimberlitic soils associated with grassy vegetation anomalies (Hausel, 1998d). Other kimberlites have been recognized by the presence of Lower Paleozoic xenoliths as well as mantle and lower crustal xenoliths and nodules of peridotite, pyroxenite, eclogite, granulite, and/or megacrysts of pyrope, ilmenite, and/or diopside scattered on the surface (McCallum and Eggler, 1979; Hausel and others, 1979).

To date, more than 130,000 gem and industrial diamonds have been recovered from the district, with the greatest number being recovered from the George Creek, Sloan 1 and 2, and the Kelsey Lake kimberlites. The diamonds range from microdiamonds to a 28.3-carat octahedron, the 5th largest verified diamond found in the United States. The ratios of gem-quality to industrial-quality diamonds are favorable, with some deposits reporting ratios as high as 65% gemstones (**Figures 34, 35,** and **36, Plate 4**). The diamond population is dominated by colorless stones, although black, gray, brown, yellow, and fewer green and pink diamonds are reported (Rogers, 1985).

All of the kimberlites that have been tested in the State Line district have proven to be diamondiferous; however, a few remain untested! Average ore grades range from <0.5 to 46.1 carats per 100 tonnes; some bulk samples from the George Creek dikes yielded grades as high as 135.1 carats per 100 tonnes (McCallum and Waldman, 1991).

Aultman 1 and 2. Located in S/2 section 5, and N/2 N/2 section 8, T12N, R72W, the Aultman 1 and 2 kimberlites are the northernmost known kimberlites in the State Line district. During the early 1980s, bulk samples collected from these kimberlites by Cominco American, Incorporated yielded grades of only 1.09 carat per 100 tonnes for the Aultman 1, and 0.33 carat per 100 tonnes for the Aultman 2. These two kimberlites are located in a treeless area and intrude a facies of the Sherman Granite. They are outlined by the presence of blue ground, kimberlitic indicator minerals, and a few lower Paleozoic limestone xenoliths scattered though the grass. Reclaimed trenches expose some blue ground, making these intrusives relatively easy to spot.

Chicken Park kimberlites, Colorado. These are entirely located in Colorado, in SW section 36 and SE section 35, T11N, R73W, and N/2 section 2, T10N, R73W. The Chicken Park kimberlites include three relatively small blows of lower diatreme and upper hypabyssal facies kimberlite and one dike of hypabyssal facies kimberlite that all lie along a northeasterly trend. The largest intrusive is a small blow about 250 feet long and 160 feet wide.

Bulk samples from Chicken Park yielded 306 diamonds from a 296-tonne sample, yielding an average ore grade of 6.7 carats per 100 tonnes. The largest recovered diamond was a 2.6-carat industrial stone (McCallum and Waldman, 1991).

Diamond Peak kimberlites, Colorado. These kimberlites are entirely in Colorado and lie immediately south of the Colorado-Wyoming border in SE section 26 and SE section 35, T12N, R73W. The DP1 kimberlite occurs in a small alluvial valley marked by limestone xenoliths with weathered kimberlite in animal burrows (Carlson, 1983). The DP2 is reported to be a small intrusive (<200 feet in diameter) marked by a topographic depression with an overlying vegetation anomaly. It is not known if any diamonds have been recovered from these intrusives.

Ferris kimberlites. These two kimberlites are located in N/2 section 9, T12N, R72W, on private land and have been inaccessible in past years. The Ferris 1 kimberlite is outlined by numerous lower Paleozoic limestone xenoliths adjacent to the west bank of Fish Creek, and the Ferris 2 kimberlite occurs as a small dike with exposures of weathered hypabyssal facies kimberlite along the east bank of Fish Creek. Apparently, neither of these has been tested for diamonds.

Several geophysical targets located between the Aultman and Ferris kimberlites and located east of the Ferris kimberlites are suggestive of *blind,* near-surface kimberlite intrusives (Paterson and MacFayden, 1984). None of the geophysical anomalies have been drilled (Hausel and others, 1997).

George Creek kimberlites, Colorado. These intrusives are located entirely in Colorado, a few miles southwest of Kelsey Lake (S/2 section 21 and N/2 section 28, T11N, R74W), and do not crop out on the surface. These dikes were recognized from geophysical surveys, and were later designated as the K1, K2, and K3 intrusions. The intrusives contain hypabyssal macrocrystal phlogopitic kimberlite, and range from several hundred to about 3000 feet in length, with widths ranging from inches to 13 feet.

The dikes were diamond-rich and yielded more than 86,000 diamonds during bulk sample tests by Superior Minerals Company. Bulk sample tests ranged from 18 to 135 carats per 100 tonnes. The K1 and K2 dikes yielded average grades of 46.1 and 31 carats per 100 tonnes, respectively, which are the highest average grades reported in the district (McCallum and Waldman, 1991).

Diamonds recovered from the property showed a low degree of resorption, and included octahedra, macles, aggregates, and dodecahedra (tetrahexahedra). The color of the stones included a high proportion of colorless diamonds as well as some yellow, brown, green, and gray diamonds (Falk, 1992). Although the majority of the diamonds were small, diamonds larger than 1 carat were recovered–the largest was 2.14 carats (U.S. Diamond Corporation, press release, 1996).

Kelsey Lake kimberlites. Commercial diamond production in the State Line district began in 1996, after Redaurum Ltd. placed two of the Kelsey Lake kimberlites (KL1 and KL2) into production. These lie on both sides of the Colorado-Wyoming state line in section 20, T12N, R72W. Much of the property is located in Colorado and most of the production has been from Colorado; however, diamonds have also been recovered from Wyoming. At least 26.35 carats (Harold Kemp, personal communication, 1997), including a 6.2-carat diamond (Howard G. Coopersmith, personal communication, 1997), have been recovered from the Wyoming side of the property.

The Kelsey Lake group includes irregularly shaped pipes and fissures of diatreme facies kimberlite with zones of hypabyssal facies and fragments of crater facies kimberlite (Coopersmith, 1993). The kimberlites, and some alluvial material eroded from the pipes, have yielded many high-quality diamonds heavier than 1 carat in weight. Some of the larger recovered stones have included gemstones weighing 6.2, 9.4, 10.48, 11.85, 14.2, 16.9, 28.18, and 28.3 carats (**Figure 34, Plate 4**). The diamonds have predominantly octahedral habit, and many are colorless, although some honey-brown gemstones have been recovered (Coopersmith and Schulze, 1996).

One large stone recovered from Kelsey Lake, a 28.18-carat diamond, was cut into a diamond weighing 16.8 carats (**Figure 35, Plate 4**). This is the largest cut U.S. diamond to date. It had an estimated value of more than $250,000 (Denver Post, September 25, 1997). A minimum bid for the diamond was set at $300,000 (Billman, 1998). Another large diamond found at Kelsey Lake weighed 28.3 carats. This stone was cut into a 5.39-carat gemstone that sold for $87,000 (Anonymous, 1996).

The two largest Kelsey Lake pipes (K1 and K2) cover a total of nearly 20 acres, and were expected to yield approximately 125,000 carats per year at full production. However, by the end of 1997, only about 9000 carats had been recovered (Cappa, 1998). The Canadian Mines Handbook (1999) reported 1997 production at 4520 carats. A resource of 16.9 million tonnes of diamondiferous kimberlite to a depth of 320 feet has been outlined in two pits (Howard G. Coopersmith, personal communication, 1997).

The Kelsey Lake mill is designed to operate 24 hours a day at a rate of 195 tonnes per hour, and process approximately 40,000 to 50,000 tonnes per month (Coopersmith and Schulze, 1996). The mill uses four rotary diamond pans. The final diamond extraction occurs on two vibrating grease tables (Howard G. Coopersmith, personal communication, 1997). The Great Western Diamond Company plans to add a Sortex® diamond x-ray sorter into the mill circuit.

Maxwell pipes, Colorado. These two kimberlites lie in Colorado near the Wyoming border west of Kelsey Lake in section 24, T12N, R73W. The Maxwell 1 forms a topographic depression marked at the surface by limestone nodules and kimberlitic indicator minerals in the soil. The intrusive covers an area of about 5.6 acres. The Maxwell 2 also forms a topographic depression and is marked by a pronounced vegetation anomaly (Carlson, 1983). Small grab samples of the kimberlites yielded some diamonds.

Moen kimberlite, Colorado. At least one kimberlite, known as the Moen kimberlite, occurs in section 31, T12N, R71W, near Highway 287 in Colorado. It is not known if this intrusive has been tested for diamonds.

Nix kimberlites, Colorado. A group of four small intrusives, located south of the Wyoming border in section 14, T12N, R72W, form the Nix cluster of kimberlites. These include the NX1 and NX3 kimberlites which are primarily brecciated diatreme facies kimberlite, and the NX2 and NX4 kimberlites which are massive hypabyssal facies kimberlite porphyries. A 300-pound sample collected from two of the kimberlites yielded microdiamonds (McCallum and others, 1977).

Pearl Creek, Colorado. Pearl Creek is located south of George Creek in Colorado. Multiple dikes, up to 2 feet thick, are reported on the property. Geophysical surveys indicate the dikes have a strike length of 6200 feet. Microdiamonds were recovered from a 115-pound sample collected from the property (U.S. Diamond Corporation, press release, 1996).

Schaffer complex kimberlites. A group of kimberlite diatremes and blows, known as the Schaffer complex, is located in sections 16, 21, and 22, T12N, R72W, in the Wyoming portion of the State Line district. These are all diamondiferous, and were named the Schaffer 3, 5, 5A, 5B, 5C, 5D, 10, 12A, 12B, 13, 15, 16, 17, 18, 19, and 20 kimberlites (Hausel and others, 1981). The kimberlites are deeply weathered and poorly exposed, and occur as sporadic blue ground associated with some vegetation anomalies (Hausel and others, 1979).

The largest two diamonds recovered from the Schaffer complex weighed 0.985 carat and 0.86 carat, respectively, and were recovered from the southern part of the complex (**Figure 37, Plate 4**). The 0.86-carat diamond was a high-quality, white, transparent fragment from a larger diamond. The diamonds from the Schaffer group ranged in value (using 1980 prices for the uncut gemstones) from $40.30 to $270 per carat (**Table 3**).

Table 3. Some gem-quality diamonds recovered from State of Wyoming property in the Wyoming portion of the State Line district by Cominco American Incorporated. Color grades range from D (exceptional white +, blue-white), E (exceptional white), F (rare white +), G (rare white), H (white), I-J (slightly tinted white), K-L (tinted white), M-R (tinted color), R-S-X (dark-yellow cape). Diamond clarities range from VVS (top grade, flawless), VS (top grade), SI (middle grade, inclusions can be identified with a watchmakers' eyeglass), and IMP (lower grade, imperfect) (see Bruton, 1978). NA indicates not appraised.

Specimen Number	Weight (carats)	Color	Clarity
A1-1	0.012	G-H-I	SI-IMP
A1-3	0.025	F-G-H	SI-IMP
A1-4	0.041	I-J-K	SI-IMP
A1-5	0.042	G-H-I	VVS
A1-6	0.046	Lt. Brown	VS
A1-9	0.054	I-J-K	IMP
A1-13	.0157	G-H-I	IMP
A1-15	0.213	Lt. Brown	IMP
A1-16	0.296	I-J-K	IMP
A1-18	0.767	G-H-I	SI
A1-19	0.86	G-H-I	SI
A2-9	0.026	G-H-I	IMP
A2-10	0.01	G-H-I	VS
A2-11	0.01	G-H-I	SI
A2-12	0.017	G-H-I	SI-IMP
A2-13	0.024	I-J-K	IMP

Table 3. (continued)

Specimen Number	Weight (carats)	Color	Clarity
A2-14	0.019	F-G-H	SI
A2-15	0.022	I-J-K	IMP
A2-17	0.026	D-E-F	VVS
A2-18	0.032	G-H-I	SI
A2-19	0.026	F-G-H	SI
A2-20	0.027	I-J-K	SI-IMP
A2-24	0.039	G-H-I	IMP
A2-25	0.063	G-H-I	IMP
A2-26	0.05	I-J-K	SI
A2-33	0.067	Lt. Brown	SI-IMP
A2-34	0.074	G-H-I	IMP
A2-36	0.087	G-H-I	SI-IMP
A2-37	0.076	I-J-K	IMP
A2-38	0.15	G-H-I	SI
A2-46	0.244	G-H-I	VS
A2-47	0.226	G-H-I	IMP
A2-48	0.353	Lt. Brown	SI-IMP
A2-49	0.773	I-J-K	IMP
A3-2	0.019	G-H-I	SI-IMP
A3-4	0.056	I-J-K	IMP
A3-8	0.114	G-H-I	IMP
A3-9	0.122	I-J-K	IMP
A3-12	0.164	NA	
A3-13	0.430	G-H-I	SI-IMP
A4-1	0.024	G-H-I	VS
A4-3	0.05	G-H-I	IMP
A4-4	0.048	F-G-H	VVS
A4-7	0.055	NA	
A4-8	0.057	G-H-I	IMP
A4-9	0.092	F-G-H	VS
A4-14	0.053	NA	
A5-2	0.035	I-J-K	IMP
A5-3	0.05	I-J-K	IMP
A5-5	0.055	I-J-K	IMP

Table 3. (continued)

Specimen Number	Weight (carats)	Color	Clarity
A5-6	0.064	I-J-K	IMP
A5-15	0.078	I-J-K	SI
A5-16	0.176	Lt. Yellow	VS
A6-1	0.011	G-H-I	SI-IMP
A6-3	0.023	I-J-K	IMP
A6-4	0.031	I-J-K	IMP
A6-5	0.027	I-J-K	IMP
A6-6	0.035	G-H-I	VS
A6-8	0.05	Lt. Brown	IMP

Testing of the northernmost Schaffer complex kimberlites in 1981 yielded an average ore grade of 0.68 carat per 100 tonnes, whereas the entire complex yielded an average grade of only 0.56 carat per 100 tonnes (McCallum and Waldman, 1991). Individual bulk samples yielded grades as high as 9.74 carats per 100 tonnes.

Sloan kimberlites, Colorado. Six kimberlites are found in or adjacent to the Rabbit Creek drainage, about 10 miles south of the Colorado-Wyoming border in sections 3, 9, 10, 12, 15, and 16, T10N, R72W. These include the Sloan 1, 2, 3, 4, 5, and 6.

The Sloan 1 intrusive, which consists of diatreme facies kimberlite, has an areal extent of 500 by 1800 feet and is one of the largest pipes in the district. The Sloan 2 is a dike-like blow about 200 by 2000 feet in areal extent and consists primarily of hypabyssal facies kimberlite (McCallum and Mabarak, 1976; Shaver, 1994).

Diamonds recovered from the Sloan 1 and 2 range from well-preserved octahedra to highly resorbed tetrahexahedra with colors ranging from D to E (Dummett and others, 1988). In addition to colorless diamonds, white, black, gray, yellow-brown, amber, and rare green, pink, and blue diamonds have been recovered (Otter and Gurney, 1989).

Bulk sampling of the Sloan 1 and 2 kimberlites by Superior Minerals (and later with their joint venture partner Lac Minerals) resulted in the recovery of 21,546 diamonds in the 1980s (Oliver, 1990). More recent sampling of the Sloan 2 kimberlite by Royal Star Resources yielded 9034 diamonds larger than 1 mm with a combined weight of 342.17 carats. These were recovered from 3300 tonnes of rock resulting in an average ore grade of 12.68 carats per 100 tonnes (Shaver, 1994). Cumulative production from the Sloan 1 and 2 kimberlites has totaled 30,580 diamonds.

The largest diamond recovered from the Sloan 1 and 2 kimberlites was a 5.51-carat gemstone (**Figure 36, Plate 4**) (Bernhard Free, personal communication, 1994). Shaver (1994) estimated that this diamond would produce a clear, white, brilliant-cut stone weighing at least 2 carats. In addition to diamonds, these kimberlites also contain abundant chrome diopside and pyrope garnet, as well as rare specimens of mantle fragments. Some of these mantle fragments are of value to collectors, such as one hand-specimen-sized diamondiferous eclogite nodule which had an estimated diamond grade of 2,100,000 carats per 100 tonnes (Schulze, 1992)!

The Sloan 5 intrusive north of the Sloan 1 and 2 was sampled in 1982. In total, 474 diamonds totaling 9.09 carats were recovered from 904 tonnes of kimberlite, for an average grade of 1.0 carat per 100 tonnes. Bulk sampling of the nearby Sloan 6 intrusive resulted in the recovery of 215 diamonds with a total weight of 6.72 carats from 500 tonnes of kimberlite, for a grade of 1.3 carats per 100 tonnes (McCallum and Waldman, 1991).

Medicine Bow Mountains

Several interesting anomalies have been identified in the Medicine Bow Mountains (see Hausel and others, 1997). One of the more interesting was the Boden diamond placer on Cortez Creek within the Medicine Bow National Forest. Another diamond was reported from a drill core recovered in the northern part of the range. *Recommended maps: U.S. Geological Survey topographic maps of the Saratoga 1:100,000-scale Quadrangle and the Turpin Reservoir 1:24,000-scale Quadrangle.*

Cortez Creek. In 1977, two gem- to near-gem-quality octahedral diamonds (**Figure 38, Plate 5**) were discovered in a gold placer on Cortez Creek (N/2 section 2, T16N, R81W) in the northern Medicine Bow Mountains (Hausel, McCallum, and Roberts, 1985). The diamonds were found by Paul Boden of Saratoga, Wyoming, and recovered from concentrates in a long tom used to extract gold. The source of the diamonds has not been found.

Access to Cortez Creek is by way of State Highway 130. From Highway 130 along the western flank of the Medicine Bow Mountains (just 2 miles northwest of Ryan Park), turn northeast onto the Brush Creek road (Forest Service Road 100) to the Mullison Park area. At 4 to 4.5 miles, Cortez Creek lies to the east.

Northern Medicine Bow Mountains. A diamond was recovered from drill core in Precambrian quartz-pebble conglomerate by Superior Minerals during exploration for a Witwatersrand-type gold deposit in the northern Medicine Bow Mountains (Tom E. McCandless, personal communication, 1995).

Powder River Basin

Gillette area. Microdiamonds and some garnets were recovered from a coal seam in the Gillette area in the Powder River Basin of northeastern Wyoming (Finkelman and Brown, 1989). The source of the diamonds remains unknown.

Wind River Range

South Pass. A diamond was reportedly found in the late 1800s in the Beaver placers of the South Pass-Atlantic City mining district, southern Wind River Range (Hausel, 1991a). According to historical newspaper reports, $1,000 was offered for the stone.

Tourist Creek area. A diamond measuring approximately 2 cm across was reportedly found on a flat between Tourist and Well Creeks (Latitude 43°12'30" North, Longitude 109°43' West) one mile west of Mount Solitude in the central Wind River Range. This stone, known as the Moore diamond, was verified by a jeweler but was later destroyed in a ranch fire (J. David Love, personal communication, 1981). *Recommended map: U.S. Geological Survey topographic map of the Gannett Peak 1:24,000-scale Quadrangle.*

FELDSPAR (see LABRADORITE)

FLUORITE

Fluorite (CaF_2) is uncommon in Wyoming. But where found, it is primarily massive, granular, and less commonly found as small cubes. Fluorite is usually of interest to mineral collectors, but is not considered a gem or semi-precious gem due to its lack of hardness. On the Mohs scale, fluorite has a hardness of only 4 and is easily scratched.

Because of its sometimes brilliant luminescence, fluorite is often prized by collectors of fluorescent minerals (the word fluorescence is derived from the mineral fluorite) (Vanders and Kerr, 1967). Fluorite typically luminesces violet-blue under ultraviolet light.

Fluorite is often translucent to transparent, purple to blue in color, but has been reported in yellow, blue-green, pink, white, and colorless cubes and granular masses with perfect octahedral cleavage. It is found associated with some alkalic igneous rocks in northeastern Wyoming and associated with some hydrothermally altered granites in southeastern Wyoming.

Bighorn Basin

Cody area. Colorless to pale yellow fluorite is found in botryoidal layers associated with late Cenozoic tuffa deposits and paleo hot springs, and solution cavities in the Mississippian Madison Limestone on the slopes of Cedar Mountain west of Cody (SE section 5, T52N, R102W). Fluorite layers up to 1 inch thick are exposed in a road cut and are closely associated with white, radiating, fibrous barite crystals up to 0.5 inch long (Wayne M. Sutherland, personal field notes, 1988).

Black Hills

The Black Hills of northeastern Wyoming include alkalic igneous intrusions in the Bear Lodge Mountains (district), Mineral Hill district, and Black Buttes mineralized area (**Figure 39**). Some fluorite has been reported in the Bear Lodge Mountains and at Black Buttes. The Black Hills region can provide a very interesting outing for mineral collectors, as the area contains numerous prospect pits where jasper, agate, amethyst, fluorite, hemimorphite, galena, sphalerite, wulfenite, copper, rare-earth-bearing minerals, gold, silver, cassiterite, and carbonatites can be found.

Bear Lodge Mountains

The Bear Lodge Mountains fluorite occurrences are found in the Black Hills National Forest north of Sundance (**Figure 40**). In this region, fluorite has been reported associated with limestones that trend northerly for about 3 miles, in a 0.5-mile-wide zone. The fluorite is massive to granular, although some fluorite cubes up to 0.25 inch in diameter have been found (**Figure 41, Plate 5**). *Recommended map: U.S. Geological Survey topographic map of the Sundance 1:100,000-scale Quadrangle.*

Beaver Creek-Sheep Mountain area. Fluorite is locally found in limestone on the north slope of a flat-topped ridge in the Sheep Mountain area (section 15,

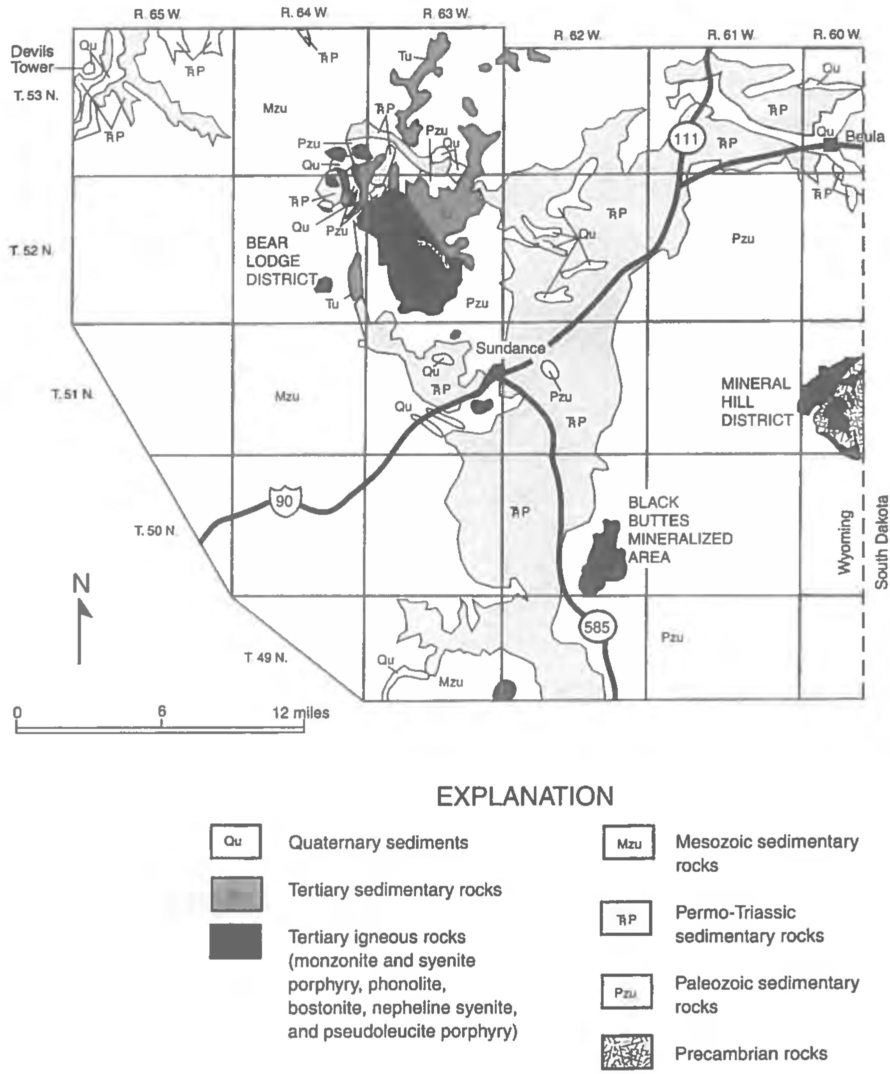


Figure 39. General geologic map of the Black Hills (from Love and Christiansen, 1985; Lisenbee, 1985).

T52N, R63W) north of Sundance. The Pahasapa Formation (Mississippian) contains flat-lying lenses of fluorite, and is a massive, blue-gray to black fossiliferous limestone which strikes easterly in this area.

Prospect pits reveal 3 to 4 feet of massive, deep purple, fluorite replacing limestone along bedding planes (Haff, 1944a). A lenticular, discontinuous breccia in the limestone contains limestone fragments in a fluorite matrix. The mineralization forms an intimate intergrowth of fluorite, calcite, quartz, and orthoclase (Osterwald and others, 1966).

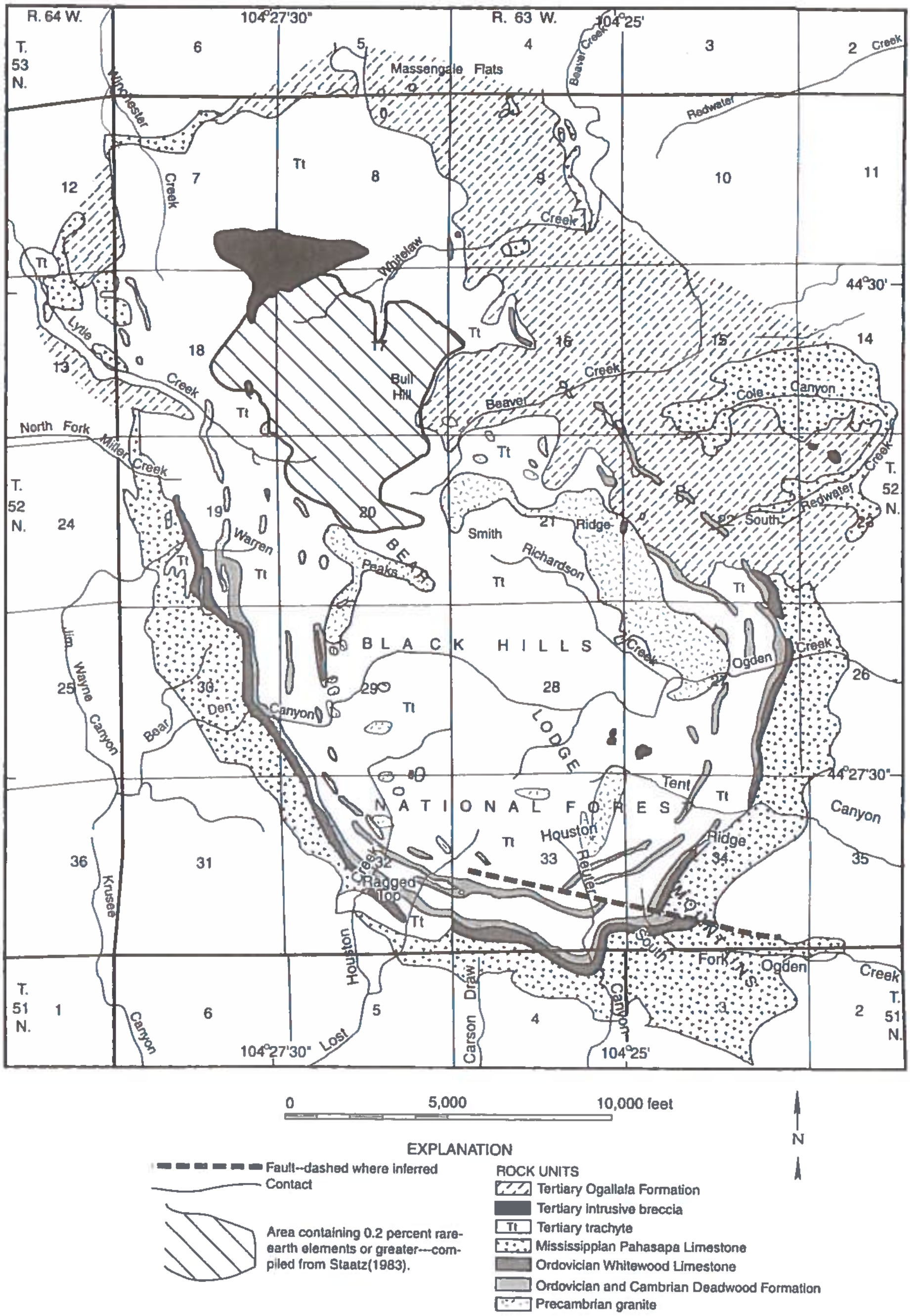


Figure 40. Generalized geologic map of the Bear Lodge Mountains (modified from Staatz, 1983).

Ogden Creek area. This fluorite occurrence is located in SW section 27, and SE section 28, T52N, R63W. It is near the crest of an east-west-trending ridge which forms the divide between Ogden and Tent creeks, five miles north of Sundance (**Figure 40**). The oldest rocks in the area are crystalline limestones or marbles. Locally, these contain discontinuous fluoritized masses of limestone that have been invaded by Tertiary trachytic porphyry. The porphyry is widespread and locally has massive, relatively siliceous, fluorite-rich zones.

Fine-grained disseminated fluorite grains are found near the contact of the limestone where it has been intruded by trachyte porphyry. Three phonolite dikes in this area cut the porphyry and limestone, but contain no fluorite.

A mineralized zone of fine-grained fluorite disseminated in marble is estimated to contain 5 to 10% fluorite. The siliceous fluorite-bearing veins in the intrusive rocks are as much as 2 feet wide and localized within breccias (Osterwald and others, 1966).

Peterson fluorite. This occurrence is located in sections 15 and 23, T52N, R63W, near South Redwater Creek six miles north of Sundance (**Figure 40**). The Pahasapa Limestone strikes northwesterly, dips 30 to 40°NE, and contains disseminated fluorite grains and lenses of fluorite that dip parallel to the bedding. Some prospect/exploration pits exposed 3 to 4 feet of massive, deep purple fluorite, although most exposures show considerably less fluorite. In a few pits, some lenses containing 60 to 90% fluorite were exposed. The fluorite lenses grade into limestone on both the hanging wall and footwall. The margins of the masses show interlayered fluorite and limestone with individual layers 0.25 to 0.5 inch thick (Osterwald and others, 1966).

Royal Purple. This occurrence is located along the Middle Fork of Houston Creek near Ragged Top (**Figure 40**) in section 5, T51N, R63W, and section 32, T52N, R63W. A Tertiary phonolite porphyry sill intrudes sandstone of the Minnelusa Formation (Pennsylvanian). The sill is about 50 to 75 feet thick, and both the sill and the sandstone trend north-south and dip 20 to 30°W.

Deep purple to black fluorite grains are disseminated in Minnelusa sandstone and are from 50 to 75 feet from the contact with the sill. On the north side of the creek, the sandstone encloses 5 to 6 lenses of fluorite that are 1 to 2 feet wide and 8 to 10 feet long. These lenses are associated with calcite, quartz, and siderite(?). Cox (1945) estimated that a faulted zone between porphyry and limestone contained 20 to 30% CaF_2 and that a zone of fluorite disseminated in coarse-grained, soft limestone and in a vein between the limestone and sandstone, contain about 30% CaF_2 (Osterwald and others, 1966).

Black Buttes

Black Buttes prospect. A prospect pit in NE section 26, T50N, R62W, exposed a contact breccia in Pahasapa Limestone (Mississippian) next to a Tertiary-age trachyte intrusion. Samples from the pit include fluorite-bearing limestone with some massive galena, jasperoid, wulfenite, and hemimorphite. Silicified limestone with minor fluorite was also found in the N/2 N/2 section 26 about 2000 feet west of the prospect pit (Hausel, 1988c) (**Figure 42**).

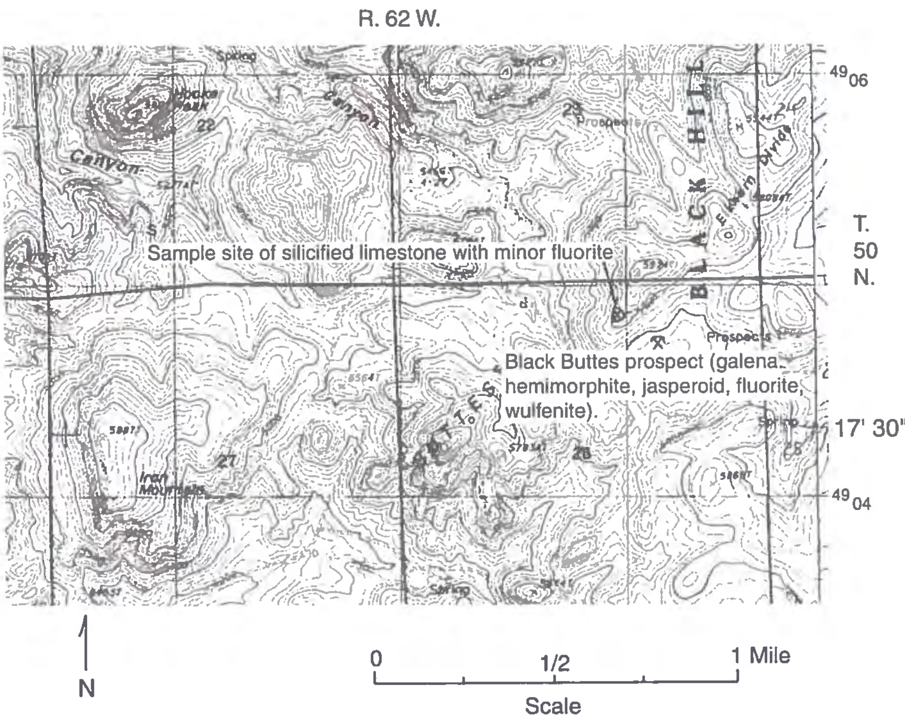


Figure 42. Location map of prospects and mines in the Black Buttes area (base map from Duling Hill Quadrangle, 1:24,000-scale topographic map).

Laramie Mountains

Bear deposit. An area measuring 150 by 100 feet contains fluorite masses 1 to 5 feet long near Middle Lodgepole Creek in the Laramie Mountains east of Laramie. At this location (SW NW section 5, T15N, R70W), Precambrian pegmatite intrudes granite and contains clear grains of fluorite, 0.8 to 2.5 inches across, with interstitial feldspar. Approximately 20 tons of fluorite were mined from the property as a by-product of feldspar mining in 1944 (Osterwald and others, 1966). *Recommended map: U.S. Geological Survey topographic map of the Laramie 1:100,000-scale Quadrangle.*

Medicine Bow Mountains

There are two fluorite occurrences reported in the Medicine Bow Mountains. Fluorite mineralization southwest of Mountain Home near Kings Canyon, Colorado, may extend northward into the southern Medicine Bow Mountains, Wyoming. *Recommended map: U.S. Geological Survey topographic map of the Saratoga 1:100,000-scale Quadrangle.*

Barber mine. This mine, located in W/2 SE section 15, T14N, R77W, near the southern flank of Sheep Mountain in the eastern Medicine Bow Mountains (**Figure 17**), was developed on a quartz vein in the Sherman Granite. Mineralized samples found on the property included hypidomorphic granular granite with traces of malachite and accessory fluorite replacing biotite. The fluorite is granular with grains ranging from 1 to 2 mm across. Other minerals found on the mine dump included ilsemannite ($MoO_8 \cdot xH_2O$), chalcopyrite, chalcocite, bornite, and cuprite (Hausel, 1997a).

Big Creek district. In this district, fluorite is an accessory mineral associated with feldspar and quartz pegmatites (see **BERYL**).

GARNET

Garnet is a common accessory mineral found in many micaceous metamorphic rocks as well as in several kimberlites in Wyoming. Less commonly, garnet has also been found in some contact replacement deposits, known as skarns.

Because of its relative resistance to weathering and disaggregation during stream transport, garnet is often found in the black sands of stream deposits downstream from its host rock. When found in the host rock, the garnets can range from tiny grains to single minerals as large as 5 to 6 inches in diameter.

Six pure end-member subspecies of garnet are recognized by mineralogists. These vary in color, specific gravity, chemistry, and index of refraction. The subspecies include pyrope [$Mg_3Al_2(SiO_4)_3$], almandine [$Fe_3Al_2(SiO_4)_3$], spessartite [$Mn_3Al_2(SiO_4)_3$], grossularite [$Ca_3Al_2(SiO_4)_3$], andradite [$Ca_3Fe_2(SiO_4)_3$], and uvarovite [$Ca_3Cr_2(SiO_4)_3$]. However, in nature, garnets typically form solid solutions, or mixtures of the end members. Because of this characteristic, many garnets are best described as a solid-solution series. For example, a garnet containing both magnesium and iron may be described as a pyrope-almandine [$MgFe_3Al_2(SiO_4)_3$] garnet, and so forth.

Garnets have relatively high specific gravity (3.5 to 4.3) and hardness (6.5 to 7.5). The high specific gravity results in garnets being found in the heavy black sand concentrates in placer deposits. They crystallize in the isometric crystal system, have no cleavage, may show parting, are typically transparent to translucent, and often exhibit well-formed dodecahedral or trapezohedral habit (**Figure 43, Plate 5**).

Garnets are typically used for abrasives, although excellent museum-quality garnets are often found. Less commonly, transparent to translucent, flawless garnets are found; these are used as semi-precious gemstones. Garnets can be red, brown, purple, purplish-red, yellowish-orange, reddish-brown, black, white, or green.

Within the Cowboy State, a variety of garnets have been reported. These include translucent to opaque almandine garnets with good dodecahedral habit from the Teton Range and chlorite pseudomorphs after garnet from the Sierra Madre near Encampment (**Figure 44, Plate 5**). These latter psuedomorphs exhibit excellent dodecahedral habit, but are opaque and completely to nearly completely replaced by chlorite and biotite mica, even though they retain the garnet crystal habit. Some extraordinary pyrope-almandine garnet megacrysts, as much as 5 to 6 inches across, from the Colorado-Wyoming State Line district have also been recovered from some diamondiferous kimberlites, but are rounded and without any crystal faces (**Figure 45, Plate 5**).

Transparent, flawless, semi-precious garnets are uncommon in Wyoming. However, several gem-quality stones have been found in breccia pipes in the Greater Green River Basin near Cedar Mountain and in anthills near Butcherknife Draw (**Figures 22** and **23, Plate 2**). The small (typically less than 6 mm in diameter), transparent, pyrope and pyrope-almandine garnets found in anthills are associated with emerald-green chromian diopside and chromian enstatite. Some collectors have faceted some of these stones, producing very attractive reddish-purple and yellowish-orange gemstones (**Figure 46, Plate 6**).

Other transparent, gem-grade garnets have been reported by the Cheyenne Gem and Mineral Society (1965) in an area 20 miles northeast of Guernsey. Many of these have apparently been cut, polished, and sold as gems.

Granite Mountains

The Granite Mountains of central Wyoming consist primarily of ancient (Archean) metamorphic rocks (schists and gneisses) intruded by younger granites immersed in Tertiary sediments. Much of the region is unexplored. However, recent investigations in the Barlow Gap area by the authors have identified several garnet amphibolite schists near banded iron formation. The garnets were all very poor quality, opaque, and reddish.

Section 16, T31N, R88W. A relatively narrow layer of garnet amphibolite with dodecahedral almandine garnets up to an inch across was found in the extreme southwestern corner of section 16, T31N, R88W. The garnets are relatively common in the amphibolite.

Green River Basin

Numerous pyrope and pyrope-almandine garnets have been found in anthills, in the Tertiary Bishop Conglomerate, in road cuts, and in a small group of breccia pipes. These are found in an area of kimberlitic indicator minerals covering a few hundred square miles in the Green River Basin (**Figure 21**). Many of these garnets are of semi-precious gemstone quality, as they are translucent to transparent, and range from red to purplish-red to yellowish-orange. The majority of the garnets found in the anthills are restricted in size (1 to 6 mm across), although larger stones have been recovered from road cuts, the Bishop Conglomerate, and the DK pipes along the southwestern margin of Cedar Mountain.

One of the better areas with abundant garnet lies in the vicinity of Butcherknife Draw north of Cedar Mountain. In this area, dozens of garnets are often found on individual anthills (see **CHROMIAN DIOPSIDE AND CHROMIAN ENSTATITE**). *Recommended map: U.S. Geological Survey topographic map of the Evanston 1:100,000-scale Quadrangle.*

Hartville uplift

The Hartville uplift in eastern Wyoming is a Precambrian metamorphic terrane, which includes mica schists and garnet pegmatites (**Figure 13**). Numerous garnets have been reported from this region, and both gemstone and abrasive (industrial) varieties are reported. *Recommended maps: U.S. Geological Survey topographic maps of the Lusk and Torrington 1:100,000-scale quadrangles.*

Haystack claim. This claim is located about 6 miles northeast of Guernsey, south of Garnet Hill in section 1, T27N, R65W. The Haystack claim was originally staked for feldspar, which was mined from granite pegmatite. The pegmatite consists of quartz, feldspar, mica, and garnet. Some of the garnets were reported to be 1 inch in diameter and euhedral (Hanley and others, 1950).

Jay Em area. Large fractured garnets are reported in outcrops about 12 miles west and 8 miles north of Jay Em, northwest of Rawhide Creek (Osterwald and others, 1966).

McGinnis Pass area. McGinnis Pass is located in the Haystack Range, approximately section 11, T27N, R65W. Several hundred clear garnet crystals were reportedly found, cut, polished, and sold as semi-precious gemstones from this area (Osterwald and others, 1966).

Laramie Mountains

Several garnet localities in the Laramie Mountains are described below, although no gemstone garnets have been reported.

Cooney Hills. Osterwald and others (1966), reported the presence of a large deposit of garnet in the Cooney Hills (section 8, T23N, R69W) west of Wheatland. According to Hagner (1944), the deposit, known as the MacDougal vermiculite property, is associated with garnet-biotite schist. Some of the garnet crystals are 2 inches in diameter. *Recommended map: U.S. Geological Survey topographic map of the Rock River 1:100,000-scale Quadrangle.*

Iron Mountain district. Several kimberlites in the Iron Mountain district (T19N, R70W) contain pyrope and pyrope-almandine garnets, as well as picroilmenite and chromian diopside (**Figure 25, Plate 2**). The garnet megacrysts are more common in a group of kimberlites along the western margin of the district.

In addition to garnet, this district is a good place to search for hand specimens of kimberlite (also see **KIMBERLITE** and **DIAMOND** sections), as some kimberlites crop out in the district and have relatively well-preserved megacrysts of olivine. The kimberlites are found on private, state, and federal land. *See Smith (1977) or Hausel and others (1997) for a map of the district.*

Owen Creek area. This area is located in sections 9 and 16, T25N, R71W (**Figure 14**), near Wheeler Flat, several miles west of Wheatland and north of Palmer Canyon. *Recommended map: U.S. Geological Survey topographic map of the Laramie Peak 1:100,000-scale Quadrangle.*

In the NW section 16, Osterwald and others (1966) reported 0.25-inch-diameter garnets found in a gully tributary to Owen Creek. These garnets weathered out of the adjacent biotite schist country rock. In the SE SE SW section 9, abundant translucent to opaque dodecahedral garnets up to 0.3 inch across are found in a NE-trending, 20-foot-thick schist layer on a south-facing slope above Owen Creek. The schist appears fibrous and weathers cream to reddish in color. Nearby, an amphibolite located west of the Big Chief mica mine (see **BERYL**), reportedly contained pyrope-almandine garnets.

State Line district. Several kimberlites in the State Line district south of Tie Siding and west of Highway 287 (T12N, R72W) host a variety of rounded (anhedral) garnets (**Figure 45, Plate 5**). Many of the garnets are pyrope, pyrope-almandine, almandine, and pyrope-grossular garnets of millimeter size. However, some pyrope-almandine garnet megacrysts collected from some of the kimberlites were fist-size (5 to 6 inches across). These megacrystal garnets are typically highly fractured and translucent, with a reddish-brown color.

Many of the other garnets collected in the district range in color from red to reddish-purple to orange-yellow to pink (see **DIAMOND**; **CHROMIAN DIOPSIDE AND CHROMIAN ENSTATITE**). Access to many of the kimberlites in the district is difficult due to mixed land ownership (*see Hausel, 1998d, for a location map).*

Tie Siding area. Several small pegmatites in section 11, T12N, R72W, were quarried for feldspar during the 1940s along U.S. Highway 287 on the eastern edge of the State Line diamond district. Locally, these pegmatites contain uncommon accessory euhedral to subhedral garnet (Osterwald and others, 1966). At one of these quarries about 500 feet east of Highway 287, a fractured, fist-size, opaque euhedral reddish-brown garnet was found (W. Dan Hausel, personal field notes, 1979).

Medicine Bow Mountains

Some relatively large, poorly-formed, translucent to opaque almandine garnets have been found in pegmatites southwest of Foxpark in the Medicine Bow Mountains (**Figure 17**). Much of this area lies within the Medicine Bow National Forest and is currently accessible. *Recommended map: U.S. Geological Survey topographic map of the Saratoga 1:100,000-scale Quadrangle.*

Big Creek district (see BERYL).

Cumberland Gulch. This occurrence is in sections 26, 34, and 35, T18N, R82W, south of Pennock Mountain, near the head of the south fork of Lake Creek. Beeler (1903b) reported a 15-foot-wide brecciated quartz vein conformable to the schistosity of quartz-biotite-schists, hornblende schists, and tourmaline-garnet-mica schists which strike westerly and dip 15°NW. No details were given as to the character of the tourmaline or garnet. The vein in Cumberland Gulch contained limonite, malachite, and some chalcocite. Some vein quartz contained gold and silver (Hausel, 1997a, p. 128; Osterwald and others, 1966, p. 43).

French Creek district. In the 1980s, a diamond exploration company reported finding abundant pyrope garnets in Iron Creek. The source of the garnets was not found.

Ione Prospect. A Precambrian pegmatite intrudes schist southwest of Foxpark in section 32, T13N, R78W. The pegmatite is formed of quartz, microcline, and muscovite with accessory albite feldspar. Some large garnets, weighing as much as 2 pounds, were found in this pegmatite. The garnets were poorly crystallized and not gem quality (Osterwald and others, 1966).

Many Values prospect. Pink euhedral garnets and orange subhedral garnets about 0.5 inch in diameter were found in the Many Values pegmatite (SE section 32, T13N, R78W). This pegmatite also contains feldspar, quartz, muscovite, magnetite, beryl, and tantalite (Osterwald and others, 1966) (also see **BERYL**).

Muscovite pegmatite. Andradite garnet is found as a minor accessory mineral in the Muscovite pegmatite, also located in section 32, T13N, R78W. (Osterwald and others, 1966) (also see **BERYL**).

Sierra Madre

Several garnet localities have been reported in the Sierra Madre, west of the Medicine Bow Mountains (**Figure 7**). This area lies within the Medicine Bow National Forest and contains numerous old mines that were developed primarily for copper, but also included other mineral resources.

Before searching the district for garnets, the collector should obtain a copy of Houston and Graff's (1995) map of the Sierra Madre, as biotite garnet schists are common within the Silver Lake Metavolcanics. In addition to garnet, the Sierra Madre has many other rocks and minerals of interest to the collector (see Hausel, 1997a). *Recommended maps: U.S. Geological Survey topographic map of the Saratoga 1:100,000-scale Quadrangle; Houston and Graff, 1995.*

Oldman garnets. This occurrence is located about 1.5 miles south of Encampment along the Copper Creek road in NE section 14, T14N, R84W. A narrow (typically less than 10 feet wide) garnet chlorite schist on both sides and perpendicular to the road trends northwesterly and is about 1/2 mile south of the Oldman Ranch. Most of the schist lies east of the road. W. Dan Hausel traced the schist over a distance of approximately 2000 feet. The garnets are actually large, dodecahedral, chlorite pseudomorphs after garnet (Osterwald and others, 1966). Some pseudomorphs as large as 3 inches in diameter have been found in recent years (**Figure 44, Plate 5**). Many of the garnet pseudomorphs average 1 to 2 inches across and are easily separated from the schist. Portions of the interior of the pseudomorphs contain preserved, reddish-brown, almandine garnet. *Recommended map: U.S. Geological Survey topographic map of the Encampment 1:24,000-scale Quadrangle.*

Section 8 mine. This area is located in SE section 8 and NE section 17, T14N, R85W. Sometime near the turn of the 19th century, a shaft was sunk on an exhalitive massive sulfide in an attempt to mine copper. Samples from the historical mine consisted of banded chert with alternating layers of massive sulfide (pyrite, chalcopyrite, bornite, and cuprite). The massive sulfide is hosted by mafic (amphibolite) schist and garnet biotite schist of the Silver Lake Metavolcanics. The amphibolites contain large *turkey track*, bladed, radiating amphiboles in a muscovite-sericite schist with 1/8-inch-diameter almandine garnets. Some of the biotite schists in this area also contain large 1/4- to 1/2-inch-diameter porphyroblasts of opaque, fractured, reddish-brown subhedral to euhedral almandine garnet (Hausel, 1997a).

Wind River Canyon

Wind River Canyon. Excellent rounded transparent grains of garnet are found in anthills along the east side of Highway 789 in Wind River Canyon north of Shoshoni. These are reported to be pyrope and almandine garnets (Max Ruby, personal communication, 1999).

GOLD (SPECIMEN GRADE)

Gold is a precious metal of very high value that is used in many forms of jewelry as well as in many industrial applications. The metal is distinct, warm yellow, and is soft, sectile, and malleable; thus, it can be cut and molded. Because of its high specific gravity (15 to 19.3), it is easily recovered in gold pans and in other concentrating equipment designed to trap heavy minerals. Gold crystallizes in the isometric crystal system, but good specimens of gold crystals are essentially unheard of in Wyoming. Most of the gold found in the state occurs as fracture-fillings in quartz veins, rods and flakes on limonite, and flakes and nuggets in stream deposits.

Often, the lay person will mistake muscovite and sericite mica for gold in a gold pan (Hausel, 1999a). The mica tends to concentrate with heavy minerals (black sands) in the gold pan, but will roll in the water along the bottom of the pan during agitation due to its low specific gravity. Gold flakes will lie on the bottom of the pan and will not roll during panning.

There are many places to find gold in Wyoming, and many of these have been described by Hausel (1989, 1996b). Collectors typically search for gold nuggets and specimen-grade gold samples, as these make attractive additions to mineral collections, and they typically have relatively high intrinsic value. For example, some gold nuggets are worth two to three times the spot price of gold.

The majority of the gold nuggets found in Wyoming have been from the South Pass region of the Wind River Range. Another notable place for nuggets has been the Douglas Creek district in the Medicine Bow Mountains (Hausel, 1996b). Some nuggets have been reported from the Mineral Hill district in the Black Hills, and a few from the Encampment district in the Sierra Madre.

Specimen-grade samples of gold-bearing quartz typically consist of rusty or milky quartz with fractures filled with gold. Some of the better specimen-grade material has been found in the South Pass region. Other areas that have produced good specimens of gold-bearing quartz include the Medicine Bow Mountains, Seminoe Mountains, Sierra Madre, and the Mineral Hill district of the Black Hills. In addition to nuggets and specimen-grade gold-quartz samples, flour and flake gold have been recovered from numerous locations in the state.

Medicine Bow Mountains

The Medicine Bow Mountains in southeastern Wyoming have yielded some attractive specimen-grade gold-quartz samples and many nuggets.

Some of the better places to search for gold lie along Douglas Creek and some of its tributaries. Specimen-grade gold-quartz samples have also been found at some historical mines.

Publications that will be of use while searching this region for mineral specimens include reports and maps by Hausel (1989, 1993, 1994a, 1997), Curry (1965), and McCallum and Orback (1968). Recommended maps: U.S. Geological Survey topographic map of the Saratoga 1:100,000-scale Quadrangle and U.S. Forest Service map (1/2"=1 mile) of Medicine Bow National Forest.

Bear Creek. This occurrence is located south of Foxpark in T13N, R78W. Several gold nuggets (0.5 to 1 inch in length) were reportedly found in this drainage near State Highway 230 (Robert E. Jones, personal communication, 1988).

Douglas Creek district. This district lies in the heart of the Medicine Bow Mountains in Ts13 and 14N, R79W, and includes Douglas Creek and many of its tributaries (**Figure 47**). Apparently, some of the better ground was located under the present Rob Roy Reservoir north of Keystone. Historical reports indicate that about 4000 ounces of gold were mined in this district, with individual nuggets weighing up to 3.4 ounces (Hausel, 1989). Each year, many additional nuggets are found in this region along with some gold flakes (**Figure 48, Plate 6**).

Several nuggets up to 0.5 inch across have been recovered immediately downstream from the Bobbie Thomson campground during the past decade by prospectors using small hobby suction dredges. Some pyrope garnets have also been recovered with the gold. In addition, gold can be recovered from stream-deposited gravels along the stream banks adjacent to Douglas Creek in this region.

Keystone-Florence mines. The Keystone and Florence mines located in section 22, T14N, R79W, were developed on a gold-bearing shear zone in quartz diorite. The gold was found in the mylonites associated with quartz, pyrite, and pyrrhotite. Some samples of specimen-grade gold-bearing quartz have been recovered from the property in past years. Periodically, samples of quartz with boxworks containing visible gold are found (Hausel, 1993a).

Seminoe Mountains

The Seminoe Mountains lie north of Sinclair, Wyoming and consist of Paleozoic and Cenozoic rocks surrounding a core of Archean granite which intrudes Archean greenstone belt supracrustal rocks (**Figure 49**). The

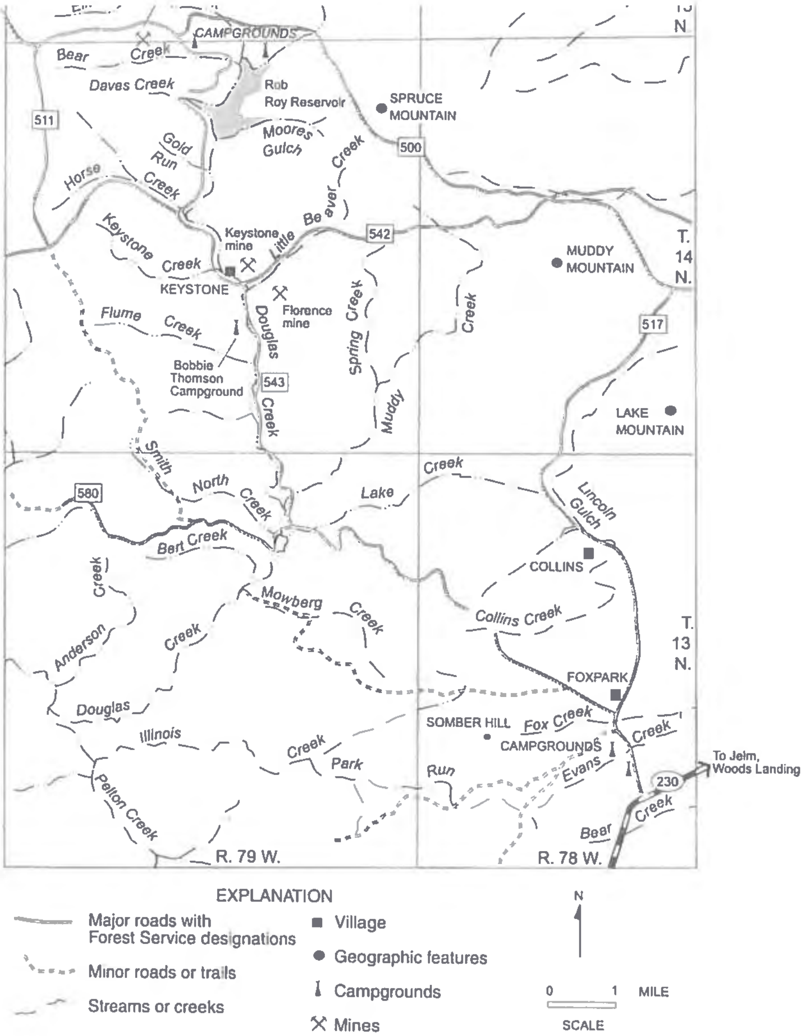


Figure 47. Location map and drainages of the Douglas Creek gold district. Douglas Creek and several of its tributaries contain placer gold, which has also been found in the alluvial material along Douglas Creek. Moore's Gulch, site of the initial gold discovery in 1868, now lies under Rob Roy Reservoir (map modified from Hausel, 1989).

rocks of the greenstone belt include amphibolite, metakomatiite, banded iron formation, and metabasalt. These rocks are considered favorable host rocks for gold. The district, however, did not produce much gold historically, although some gold (along with specimen-grade gold-bearing quartz) was recovered from a group of mines along the northeastern flank of Bradley Peak near the western edge of the Seminoe Mountains. *Recommended maps: U.S. Geological Survey topographic maps of the Shirley Basin and Medicine Bow 1:100,000-scale quadrangles; 1:24,000-scale geologic map of the Seminoe Mountains greenstone belt in Hausel (1994b).*

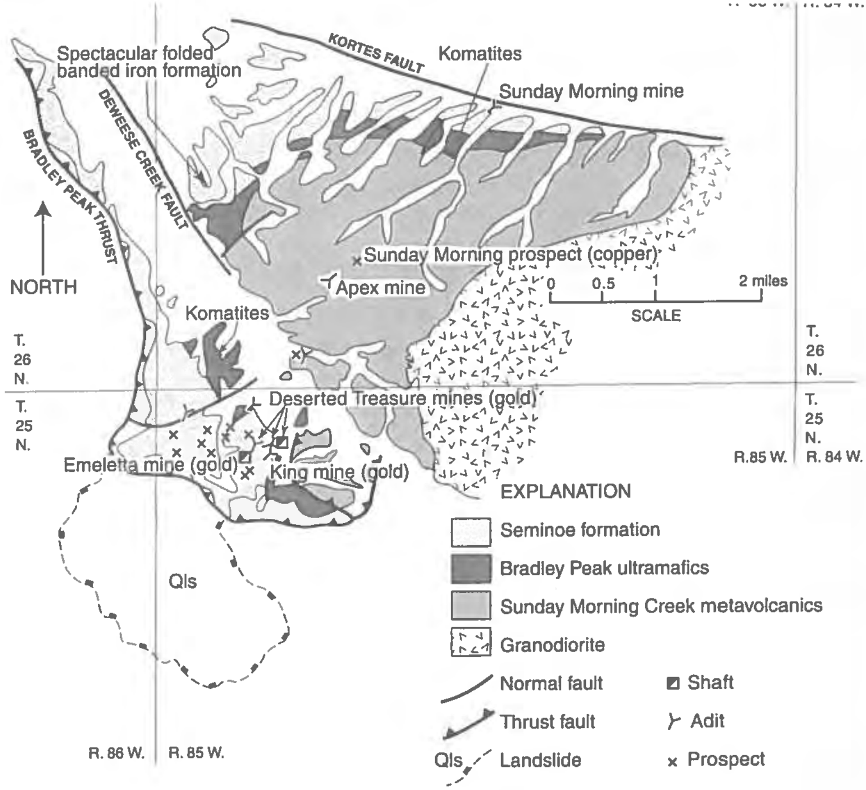


Figure 49. The Seminoe Mountains district showing locations of known mines (modified from Hausel, 1997).

Penn mines. This group of historical mines, located in section 6, T25N, R85W, included the King, Deserted Treasure #1, and Deserted Treasure #2 mines along the northeastern flank of Bradley Peak, some 30 miles north of Sinclair. These were developed on narrow quartz veins in amphibolite and mafic schist, and contain some relatively rich ore shoots (Hausel, 1994b). When examined by the senior author in 1981, several specimens of quartz with visible gold were found on the mine dumps. Following a report of the discovery, the mine dumps were picked over by dozens of geologists and prospectors; it is now difficult to find any good specimens on the surface of the dumps. However, the area still remains a potential site for the discovery of other collectable specimens, particularly those buried in the mine dumps and in nearby quartz veins.

The gold-bearing quartz specimens typically consist of milky quartz with some minor carbonate and boxworks after pyrite. Nearby Deweese Creek, which drains the Penn mines area, in all probability contains gold, including nuggets. However, the drainage shows little or no evidence of ever being prospected. Some gold has also been found in modern drainages along the northern flank of the Seminoe Mountains, and in a paleoplacer deposit east of the North Platte River in the Miracle Mile area. It appears that not much prospecting has occurred in these areas (Hausel, 1994b).

Sierra Madre

Gold nuggets and specimen-grade gold have been reported at several places in the Sierra Madre. Mulkey (1999) reported 399 nuggets were found in this region in recent years. The nuggets were probablyfound on Jim and Strawberry Creeks and nearby drainages (Rick Mattingly, personal communication, 1999).

Purgatory Gulch mines. These mines are located in section 1, T13N, R84W, and section 36, T14N, R84W. Some remarkably rich gold specimens were found here (Beeler, 1905a). According to Armstrong (1970), a 10-foot-wide free-milling gold vein was struck on Purgatory Gulch (**Figure 8**). Assays ran as high as 6 opt (ounces per ton) Au. Samples recently collected from the Golden Eagle vein contained visible gold. One sample of boxwork quartz (without visible gold) was assayed and yielded 40.63 ppm Au (1.2 opt) and 3.62 ppm Ag (Hausel, 1989, 1992). Although Purgatory Gulch downslope from the Golden Eagle vein is dry much of the year, the gulch undoubtedly contains some placer gold.

Wind River Range

The South Pass greenstone terrane near the southern tip of the Wind River Range in western Wyoming (**Figure 3**), has been and continues to be Wyoming's most productive gold district. The South Pass area is one of the more interesting regions in the state to search for gold specimens, as the district contains dozens of old mines, some ghost towns, and many artifacts. The district is located about 30 miles south of Lander. Numerous specimen-grade samples of auriferous quartz, as well as many gold nuggets, have been found in this region. Each year, new discoveries are made by modern prospectors searching for nuggets. For example, a 7.5-ounce nugget was recently found by a prospector from Rock Springs searching old tailings with a metal detector (**Figure 50, Plate 6**) (Toussaint, 1998; Mattingly, 1998). Another prospector recently recovered more than 100 nuggets using the same prospecting techniques.

The available historical records from the district indicate that many large nuggets have been found in this region. Some of the largest nuggets reported in the literature weighed 24, 5.3, 5.2, 5, 3, and 0.75 ounces (Hausel, 1996b). In addition, a boulder of quartz containing an estimated 630 ounces of gold was described from the South Pass area. Another nugget weighing 2 pounds reportedly ended up in a museum in Los Angeles (Ralph Platt, personal communication, 1998). Undoubtedly, numerous other nuggets have gone unreported.

The South Pass region includes a large Archean (> 2.5 Ga) greenstone belt of metavolcanic and metasedimentary rock that was folded into a tight synclinorium. Due to intense deformation, numerous quartz veins and many shear zones developed with localized ore shoots enriched in gold (Hausel, 1991a). Nuggets are commonly found downstream from many of these lodes. As a result, the collector should study the available geologic maps of the region and locate potential gold traps downstream from the shear zones. *Recommended maps: U.S. Geological Survey topographic maps of the South Pass and Lander 1:100,000-scale quadrangles; Hausel, 1991a.*

The South Pass region contains dozens of old mines and placer deposits; at one time the region was separated into numerous mining districts. Many of the early districts have now been combined into the South Pass-Atlantic City, Lewiston, Oregon Buttes, and Twin Creek districts (**Figure 51**). The Twin Creek and Oregon Buttes districts include giant paleoplacer gold deposits where small gold flakes and some flattened nuggets can be found, whereas the South Pass-Atlantic City and Lewiston districts contain lode, modern placer, and some small paleoplacers. These latter districts are favorable regions to search for nuggets and specimen-grade gold samples.

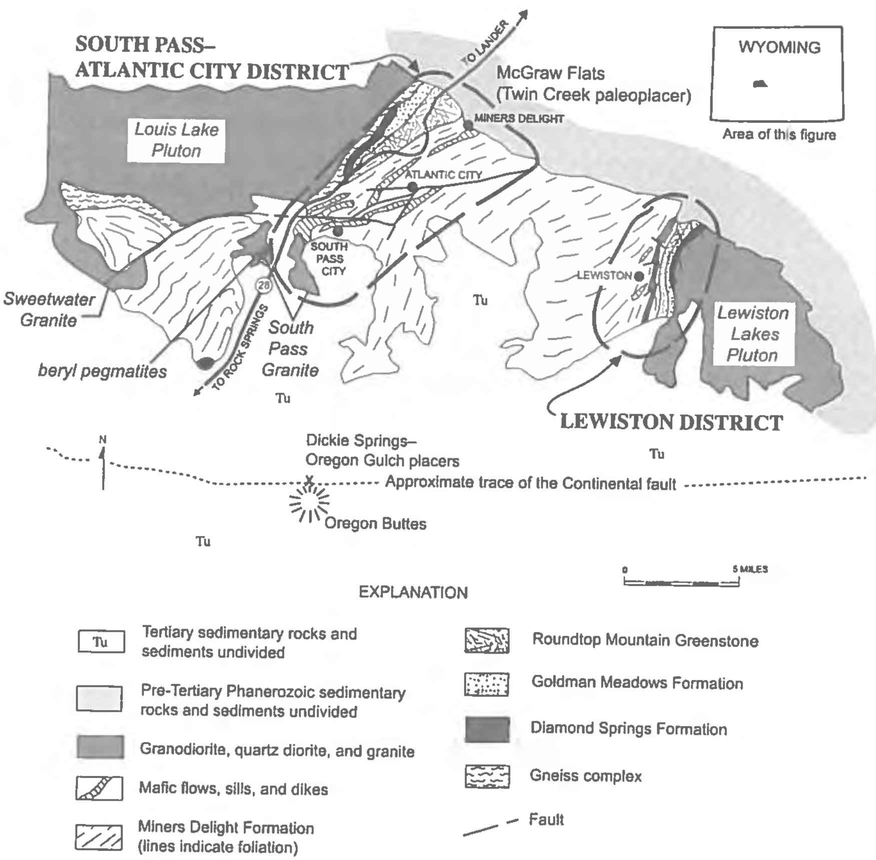


Figure 51. Generalized map of the South Pass region, southern Wind River Range (modified from Hausel, 1991a).

Many lode gold deposits in the South Pass region are localized in shear zones. Typically, these shear zones consist of distinct cataclastic zones that can be traced on the surface for a few hundred feet to as much as several thousand feet. In many of the shear zones, anomalous, low-grade gold concentrations occur along the entire strike length of the cataclastic zone with periodic ore shoots containing high-grade gold. The shoots may be localized by a number of factors, most notable are the steeply-plunging folds within the zone of intense deformation. Where enclosed by folds, the shoots continue down-plunge to unknown depths. Where such shoots are exposed at the surface, they represent excellent places to search for specimen-grade samples with visible gold. When such shoots are exposed to erosion and dissected by streams, rich placers often develop immediately downstream (Hausel, 1996b).

Lewiston district

The Lewiston district is located along the eastern flank of the South Pass greenstone belt (**Figure 52**). Several small mines were developed in shear zones hosted by metagreywacke. Some specimen grade gold-bearing quartz as well as several nuggets were found in this district. Geologically, this district is similar to the South Pass-Atlantic City district as it is located on the eastern limb of the South Pass synform and contains approximately the same rock sequence as the South Pass-Atlantic City district. *Recommended maps: Hausel, 1991a; Hausel, 1988b.*

Giblin Gulch. Giblin Gulch (SW section 33, T29N, R98W) may have been called "Two John's Gulch," and "Nugget Gulch." It is a small tributary of Strawberry Creek that cuts across the western end of the Mint-Gold Leaf shear zone (Hausel, 1988b). Several large nuggets, including nuggets weighing 5.2 and 5.3 ounces, have been reported from this area, suggesting that the drainage may overlie a hidden ore shoot on the shear zone (Hausel, 1996b) (also see ***Strawberry Creek***, below).

Gold Leaf mine. This mine is located in SE section 33, T29N, R98W. Some quartz samples collected at this mine from the Mint-Gold Leaf shear zone assayed 1.29 and 3.05 opt gold (Hausel, 1991a). In addition, samples of specimen-grade ore from the shear contained abundant stringers of visible gold in quartz.

Hidden Hand and Burr mines. These mines are located in N/2 section 8 and W/2 section 9, T28N, R98W, respectively. In 1893, a pocket of ore intersected in the Burr mine reportedly yielded 3000 ounces of gold. Samples from this pocket were reported to have been rich, assaying as high as 1690

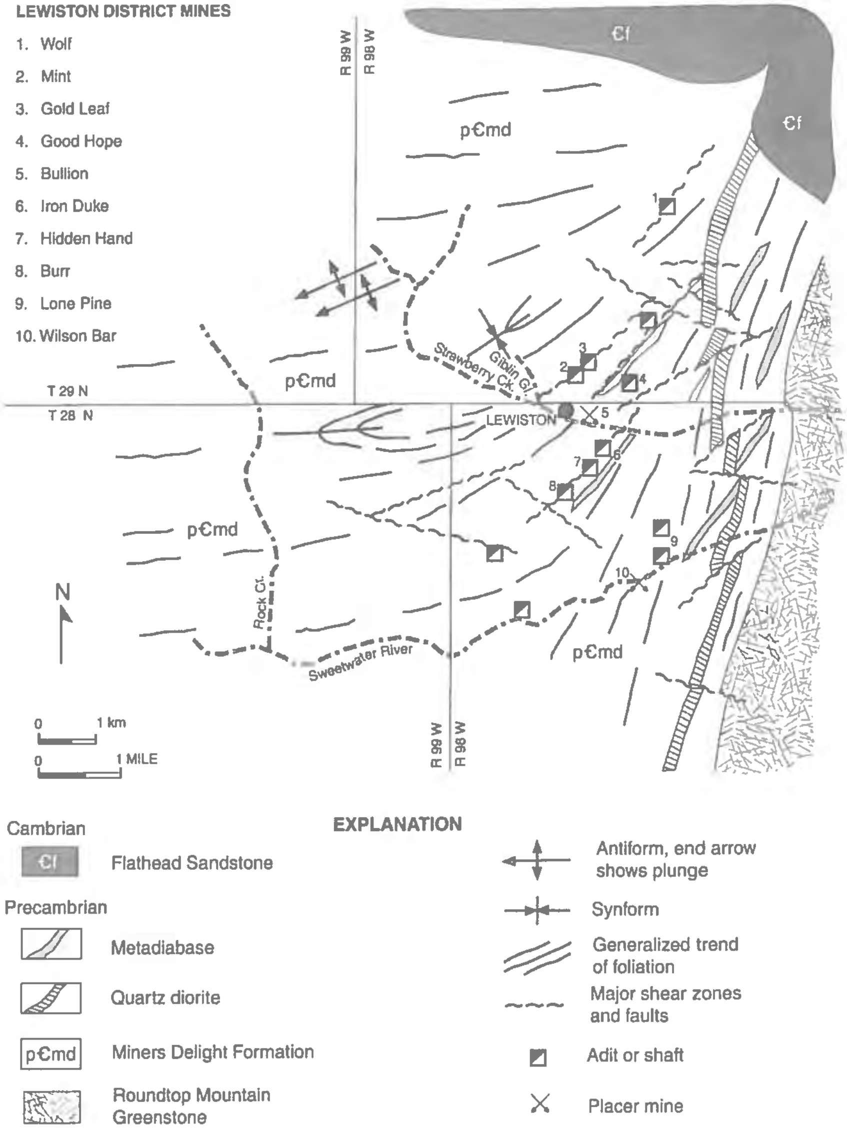


Figure 52. Generalized geologic map of the Lewiston district, South Pass (modified from Hausel, 1991a).

opt gold! According to early reports, the Burr lode averaged 2 to 3.5 opt gold. A short distance northeast of the Burr mine, the Hidden Hand mine reportedly produced several sacks of specimen-grade ore in the 1930s that yielded 75 to 3100 opt gold.

However, recent studies in the area by Hausel (1991a), could not confirm these early reports. Samples collected during this study yielded only trace amounts of gold. But because of the reputations of these mines due to the historical reports, the mine dumps may have been thoroughly picked over by collectors and prospectors through the years.

Strawberry Creek. This area is in S/2 T29N, R98W, and N/2 T28N, R98W. Strawberry Creek flows across several gold-bearing shear zones in the Lewiston district. Near the mouth of the creek where it joins the Sweetwater River, about 25 ounces of gold (which included nuggets up to 0.5 inch in length) were recently recovered by a prospector. Other placers in this region have also yielded nuggets. For example, reports indicate that two nuggets (3 and 4.5 ounces) were recovered on Two John's Gulch in 1905. In 1944, five "good-size" nuggets were found in the Big Nugget placer. Possibly, these two placers are the same as those in Giblin Gulch where the 5.2- and 5.3-ounce nuggets were found in 1932 (Hausel, 1991a, 1996b).

Wilson Bar. Rich pockets of gold were found in the Wilson Bar placer (SW section 9 and NW section 16, T28N, R98W) in 1878. A 500-foot strip of gravel mined at Wilson Bar in the late 1800s yielded 370 ounces of gold. The gold was traced upstream to the Burr lode where some specimen grade gold was reportedly found (Hausel, 1991a). In recent years, some gold, including several small nuggets, have been found by prospectors in Wilson Bar.

South Pass-Atlantic City district

The South Pass-Atlantic City district is located along the western margin of the South Pass greenstone belt (**Figure 53**). The district encloses several major gold-bearing shear zones and several significant gold placer deposits. Some of the mines in the district produced specimen-grade gold ore, and many placers downstream from these shear zones have yielded gold nuggets. *We recommend that the reader review the 1:48,000-scale geologic map by Hausel (1991a), as it contains locations of all known mines and gold-bearing shear zones in the district.*

Carissa Mine. This mine is located in NW section 21, T29N, R100W. Reports indicate that specimen-grade gold ore was found in the Carissa mine in 1908. This ore assayed as high as 260 opt gold (Hausel, 1991a). In recent years, specimens of quartz with stringers of visible gold have been dug out of the Carissa shear zone near the production shaft (see Hausel, 1999b). The mine was developed to a depth of 400 feet and produced 50,000 to 180,500 ounces of gold.

Rock Creek placer. Rock Creek runs through the heart of the South Pass greenstone belt from Atlantic City to the Sweetwater River, in Ts28 and

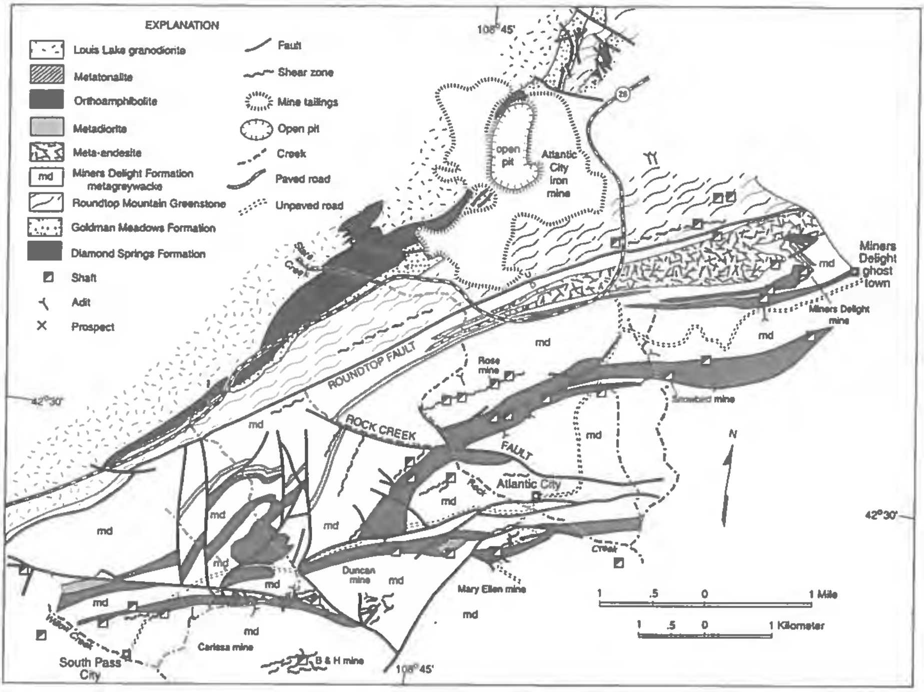


Figure 53. Generalized geologic map of the South Pass mining district (modified from Hausel, 1991a).

29N, R99W. Placers on this creek have produced many impressive, specimen-grade samples, including a "...fist-size chunk of quartz filled with an estimated 24 ounces of gold..." (Wyoming Industrial Journal, 1905, v. 6, no. 12, p. 18). Another boulder found nearby in 1905 contained an estimated 630 ounces of gold (Hausel, 1989, 1991a).

From 1933 to 1941, the E.T. Fisher Company dredged 6 miles of Rock Creek and recovered as much as 30,000 ounces of gold including nuggets as heavy as 3.4 ounces. One specimen mined from Rock Creek apparently ended up in the Los Angeles Museum of Natural History. The gold specimen reportedly weighed 2 pounds (Ralph Platt, personal communication, 1997).

In recent years, several other nuggets have been recovered from Rock Creek (Hausel, 1989). These have included a 0.75-ounce nugget (Hausel, 1996b), and a 7.5-ounce nugget found downstream from the old dredge tailings in 1996 (Toussaint, 1998). Many other nuggets have been recovered from this drainage.

Spring Gulch. Historical reports indicate that some rich pockets of gold were intersected in the Miners Delight mine along the northern margin of the South Pass greenstone belt. Some eluvial and alluvial deposits in Spring Gulch (section 32, T30N, R99W), adjacent to the mine, yielded nuggets.

Workers from Miners Delight evidently pumped water from the mine shaft into Spring Gulch to mine the drainage. Several 1- and 2-ounce nuggets were recovered along with one 6-ounce nugget. In addition to the nuggets, a small boulder of specimen-grade gold-bearing quartz was recovered in 1873 that was filled with gold. The boulder was described to be "...as large as a water bucket...and looked as if it could contain a pound of gold..." (Raymond, 1873; Hausel, 1993b).

Yankee Gulch. Yankee Gulch (section 28, T30N, R99W), also located near Miners Delight ghost town and mine, has yielded some nuggets in past years. The reported nuggets included one weighing nearly 5 ounces (Hausel, 1989).

GRUNERITE

Grunerite [$(Fe,Mg)SiO_3$], an iron-rich amphibole, produces tawny (yellow-brown), fibrous, acicular- to asbestos-form mineral specimens. The more magnesian-rich varieties are termed cummingtonites, and typically are fibrous, dark-green amphiboles $(Mg,Fe)SiO_3$. Some grunerites in Wyoming have been cut and polished producing a lapidary stone with the appearance of low-quality "Tigers Eye." However, true *Tigers Eye* requires that much of the asbestos-form mineral be replaced by quartz, and this replacement has not yet been reported in Wyoming.

Since many deposits of grunerite exist in Wyoming's greenstone terrains and supracrustal belts (i.e., South Pass, Seminoe Mountains, Elmers Rock, Copper Mountain), it is likely that some Tigers Eye will be found in the future. The grunerite is associated with banded iron formation, so the collector should obtain geologic maps of those areas and search both the iron formation outcrops and the drainages downslope from the outcrops. Some of the better samples of grunerite have been collected in the Copper Mountain district (see Hausel, Graff, and Albert, 1985) and in the Seminoe Mountains, particularly in paleoplacers and alluvium along its northern flank (see Hausel, 1994b).

Jade is the gemologist's designation applied to two distinct and unrelated mineral species, nephrite and jadeite. Of the two gemstones, only nephrite has been found in Wyoming. Such an abundance of nephrite jade has been found in the state that nephrite jade is often considered synonymous with *Wyoming Jade,* even though it is found elsewhere in the world.

Nephrite is an amphibole formed of extremely dense and compact fibrous tremolite-actinolite; *jadeite* is a pyroxene of the augite series. These two minerals closely resemble one another, and are essentially indistinguishable in hand specimen without the aid of physical tests, such as petrographic and/or XRD analyses.

Many similar appearing rocks are often mistaken for nephrite jade such as rounded, stream-worn, or wind-polished cobbles of amphibolite, metadiabase, epidotite, quartzite, leucocratic (white) granite, and serpentinite. These rocks can be distinguished from jade by any number of tests including some simple field observations. For example, amphibolite, metadiabase, and leucocratic granite typically have a granular texture that is lacking in jade; the freshly broken surface of quartzite tends to sparkle in sunlight due to the reflection of light off individual quartz grains; epidotite has a distinct pistachio green color and perfect cleavage; and serpentinite is relatively soft and often can be easily scratched with a pocket knife. In addition, serpentinite exhibits pockets or zones of weak to moderate magnetism, unlike jade.

Nephrite jade [$Ca_2(Fe, Mg)_5(Si_4O_{11})_2(OH)_2$] never shows any external structure, except where the mineral rarely pseudomorphs the habit of another mineral. For instance, in the Granite Mountains of central Wyoming near Jeffrey City, nephrite psuedomorphs after quartz have been found in a pseudohexagonal (six-sided prism) habit, but these are uncommon. Typically, nephrite occurs in irregular masses and lacks cleavage.

Microscopic examination of nephrite typically shows a mass of matted, intricately interwoven fibers. This unusual form makes nephrite jade extremely tough and resistant to fracturing [toughness can be represented by fracture strength, which is about 30,000 psi (pounds per square inch) for nephrite (Bradt and others, 1973)]. As a result, unless the rock has a schistose fabric, rounded boulders of nephrite are nearly impossible to break with a hammer. Because of its toughness and attractive appearance, nephrite, which has been termed the *axe stone*, has been prized since prehistoric times.

Only carbonado, a black granular to compact industrial form of diamond is tougher than jade. However, gem-quality diamond, the hardest known mineral found in nature, lacks the toughness of jade and is easily smashed with a hammer. It is the toughness of jade, combined with its hardness, that makes the gemstone carvable and durable.

Nephrite has a specific gravity of 2.9 to 3.02. Its hardness, as reported by Bauer (1968b) and Hurlbut and Switzer (1979), ranges from 6 to 6.5. The mineral ranges from opaque to translucent masses and has a vitreous to almost waxy luster. Nephrite is also reported to occur in black, white, and a variety of green shades.

The green color in nephrite jade is the result of iron occurring within the crystal lattice. When iron is absent, the mineral is practically colorless to cloudy white, resulting in a variety known as *muttonfat jade*. Other varieties of Wyoming jade include translucent, emerald-green *imperial jade*; *apple-green jade*; *olive-green jade*; *leaf-green jade*; *black jade*; and *snowflake* (mottled) *jade* (Bauer, 1968b). The greater commercial values are attached to the lighter green, translucent varieties.

The origin of Wyoming jade was investigated by Sherer (1969), who suggested that nephrite jade developed by metasomatic alteration of amphibole during metamorphism. According to Sherer, blocks of amphibolite were disrupted more than 2.5 billion years ago in Wyoming, and trapped in quartzofeldspathic gneiss. Portions of these amphibolite xenoliths were then altered to nephrite by metamorphic fluids derived from regional, amphibolite-grade, metamorphism. In other words, amphibole (which is represented by the mineral hornblende, a major constituent of most amphibolites) reacted with the hot metamorphic fluids (water) and produced actinolite (nephrite jade), clinozoisite, and chlorite. The general chemical reaction (unbalanced) can be written as:

$$25Ca_2(Mg, Fe)_3Al_4Si_6O_{22}(OH)_2 + 4H_2O =$$

$$Ca_2(Mg,Fe)_5Al_4Si_8O_{22}(OH)_2 + 24Ca_2Al_3Si_3O_{12}(OH) + 14Mg_5Al_2Si_3O_{10}(OH)_8$$

or

amphibole + water = actinolite (nephrite jade) + clinozoisite + chlorite

The development of nephrite jade was accompanied by wallrock alteration, resulting in a distinct mineral assemblage that can now be used by the jade prospector to help locate blind (hidden) jade deposits. Typically, this process resulted in the bleaching of the leucocratic granite-gneiss adjacent to jade, producing a mottled pink and white granite-gneiss with secondary clinozoisite, pink zoisite, pistachio green epidote, and green chlorite, as well as white plagioclase which is pervasively altered to white mica. For instance, rocks displaying this alteration assemblage are often found scattered in the gneiss between known jade deposits in the Tin Cup district in the Granite Mountains of central Wyoming, and probably indicate the presence of shallow, undiscovered jade occurrences (W. Dan Hausel, personal field notes, 1996).

individual pieces of detrital jade can vary in appearance. Some pieces may be covered with a cream to reddish-brown weathered rind that hides the characteristic color of the jade. But where naturally polished with a high-gloss waxy surface, known as *slicks*, the detrital jade is recognizable.

Large volumes of jade were recovered from central Wyoming a few decades ago; however, small quantities of the gemstone can still be found. Jade has been reported as far west as the Wind River Range (McFall, 1976), and as far east as Guernsey and the Laramie Mountains. To the north, it has been reported in the Wind River Basin, and has been found as far south as the Rawlins golf course near Interstate 80 (Hagner, 1945) and farther south in the Sage Creek Basin near the Sierra Madre.

Several large boulders have been found in Wyoming. The largest was a 14,000-pound boulder of low-quality black jade reportedly found in the Prospect Mountains (Root, 1980) at the southern end of the Wind River Range (Hemrich, 1975). Some spectacular specimens of green jade have been found in the central part of the state in the Granite Mountains and Crooks Gap regions near Jeffrey City (**Figures 54** and **55, Plate 6; Figures 56** through **58, Plate 7**).

Granite Mountains

The Granite Mountains are a deeply eroded block of Precambrian rock that once formed an extensive mountain range in central Wyoming during much of the Tertiary Period. The core of this range consists of Archean granite and granitic gneisses with interspersed amphibolites. Much of the jade found in Wyoming was discovered in this area or in nearby detrital deposits derived from the Granite Mountains. Jade is especially abundant in the southwestern part of the Granite Mountains in the Tin Cup district. Jade has also been reported to the north in the Rattlesnake Hills region, and in the Agate Flats area of the central Granite Mountains (**Figure 59**).

In addition to being found in place, detrital jade has been found in the Wind River Formation north and west of the Granite Mountains. Small flakes of detrital dark-green jade have also been found in the Split Rock Formation (along with Sweetwater agates) in the Agate Flats region. Emerald green jade has been reported in Quaternary lag gravels in the northeastern part of the Granite Mountains. Jade cobbles, pebbles, and boulders have also been reported along Cottonwood Creek at Crooks Gap, and along the flanks of Crooks and Green mountains south of the Granite Mountains uplift. Farther south, cobbles and pebbles have been found in the Red Desert area, and jade float has been reported in the Happy Spring-Warm Springs-Bull Canyon area at the western end of Crooks Mountain.

The Granite Mountains have been a favorite rock hunting region for collectors for many years because of the variety of gem and semi-precious

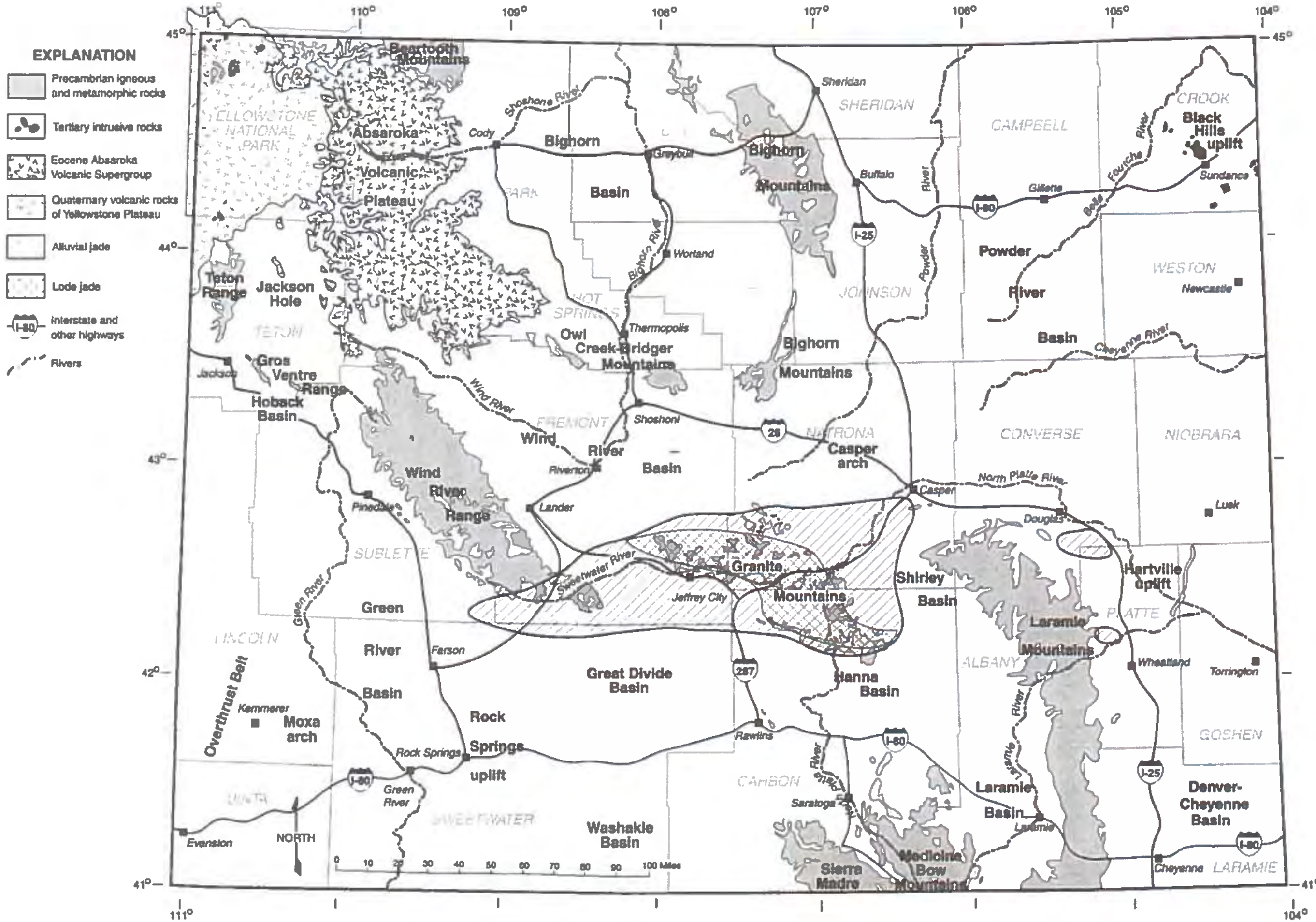


Figure 59. Jade localities of Wyoming (modified from Hausel, 1986b).

gem minerals in this area. In addition to jade, agate, jasper, ruby, sapphire, pyrite, and copper have been found in this region.

Agate Flats-Lankin Dome

These occurrences are located northeast of Jeffrey City. *Recommended maps: U.S. Geological Survey topographic maps of the Rattlesnake Hills and Baroil 1:100,000-scale quadrangles.*

Agate Flats. Small flakes and pebbles of dark-green nephrite jade, generally less than 1 inch in diameter, have been found in the Miocene Split Rock Formation in the Agate Flats region (Ts30 and 31N, R90W). This area is also known for Sweetwater agates (Love, 1970).

Lankin Creek. A vein of jade in NE SW section 3, T29N, R90W, was described as pinching from 12 inches to 3 inches in width. The vein was traced for about 15 feet (Anderson, 1972).

Beaver Rim-Sweeney Basin region

Some jade was found in the Beaver Rim-Sweeney Basin area north and northwest of the Tin Cup district near the western flank of the Granite Mountains. *Recommended maps: U.S. Geological Survey topographic maps of the Rattlesnake Hills and Lander 1:100,000-scale quadrangles.*

Muskrat Creek. This occurrence is located in section 20, T32N, R91W, along Beaver Divide near the southern margin of the Gas Hills uranium district. Boulders of dark-green and black nephrite jade were found in the Wind River Formation in this region (Love, 1970) (also see **CORUNDUM**).

Sweetwater Station. This jade occurrence is in section 26, T30N, R96W, about 4 miles west of Sweetwater Station in the vicinity of Rocky Draw. Love (1970) reported gray jade was found in aplite (light-colored granite) south of Highway 287. Some pale-blue and white sapphires (see **CORUNDUM**) were also found nearby in mica schist enclosed by gray-brown granite. The sapphires form abundant 1-inch diameter nodules in the schist, but are badly shattered.

T31N, R96W. Jade float was reported along Beaver Creek near U.S. Highway 287 (Osterwald and others, 1966).

Crooks Mountain-Green Mountain area

Jade cobbles, pebbles, and some large jade boulders were found south of Jeffrey City along Cottonwood Creek at Crooks Gap and along the flanks of Crooks and Green mountains. Jade float has also been found in the Happy Spring-Warm Springs-Bull Canyon area on the western end of Crooks Mountain.

At the western end of Crooks Mountain, nephrite was found in the Crooks Gap Conglomerate, the Wasatch Formation, and the Battle Spring Formation. Jade boulders have also been found in the Ice Point Conglomerate and in the basal conglomerate of the White River Formation west of Crooks Mountain (**Figure 60**).

Some spectacular jade specimens have been found in this region including a 955-pound boulder, a 2495-pound boulder of dark-green jade, a 460-pound boulder of medium-green jade found in the Crooks Mountain area, a 3600-pound boulder, and a 3000-pound boulder found on Hay Press Creek west of Crooks Mountain (Crippen, 1964; McFall, 1976). *Recommended maps: U.S. Geological Survey topographic maps of Baroil and South Pass 1:100,000-scale quadrangles.*

Cottonwood Creek. Apple-green nephrite boulders were found in the Wasatch and Battle Spring formations in the vicinity of Cottonwood Creek (section 7, T28N, R93W) near the northern edge of Crooks Mountain (Love, 1970).

Crooks Gap. This area includes sections 29, 30, 31, and 32, T28N, R92W. Jade float was reported in the Crooks Gap area by numerous individuals (Johnson, 1973). Love (1970) reported that apple-green jade boulders were found in the Crooks Gap Conglomerate.

Green Mountain. Jade float was reported on the south side of Green Mountain in T27N, R91W (Cheyenne Gem and Mineral Society, 1965).

Happy Spring. High-quality apple-green and black nephrite jade boulders were found in the Ice Point Conglomerate in section 3, T28N, R95W, and in section 34, T29N, R95W. However, this region has been intensely prospected and jade pebbles are now considered a rarity (Love, 1970). Many rounded fragments of black petrified wood were also found in the area.

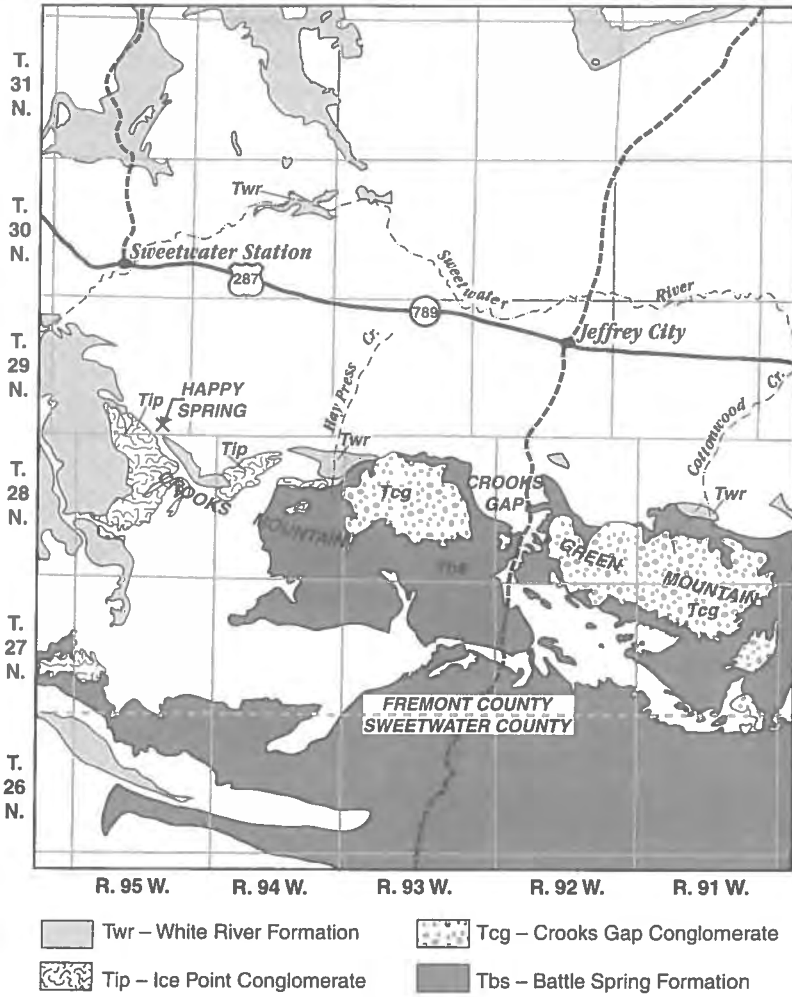


Figure 60. Generalized geologic map of the Crooks Gap-Green Mountain region, central Wyoming (modified from Love and Christiansen, 1985). Heavy dashed lines are gravel roads. Blank area (white) includes Paleozoic and Quarternery undivided.

Section 1, T28N, R94W. Love (1970) reported that nephrite jade boulders were found by Bert Rhoads in 1944 on a pediment surface along the northwestern margin of Crooks Mountain. The boulders had eroded from the Wasatch and Battle Spring formations.

Rattlesnake Hills

The Rattlesnake Hills lie along the northern margin of the Granite Mountains. This district is underlain by metamorphic rocks and granitic gneiss that form a fragment of an Archean greenstone belt and has been intruded by several Tertiary alkalic volcanics (**Figure 61**). The volcanic rocks and adjacent metamorphic rocks are considered potential hosts for large-tonnage, low-grade disseminated gold deposits (see **ORE MINERALS, Granite Mountains**) (Hausel, 1996e). Some emerald-green jade was reported in Quaternary lag gravels in the region, and muttonfat jade float was described in the Horse Creek area along the eastern margin of the Rattlesnake Hills. The source of the jade is unknown. *Recommended map: U.S. Geological Survey topographic map of the Rattlesnake Hills 1:100,000-scale Quadrangle.*

Dry Creek. According to Osterwald and others (1966) jade float was found along Dry Creek near the western end of the Rattlesnake Hills in T32N, R88W. This area was a popular locality for jade hunting in the 1940s and 50s (Cheyenne Gem and Mineral Society, 1965).

Grieve oil field. Gravels northeast of Dry Creek (center of T32N, R85W) in the Grieve oil field yielded some emerald-green jade in past years (Love, 1970). However, this area has been largely depleted, as collectors have scoured the area for the valuable, highly prized, emerald-green jade. No *in situ* source for this rare jade has been found (Cheyenne Gem and Mineral Society, 1965).

Vinegar Hill-Black Rock Mountain. This jade occurrence is located in sections 20 and 31, T31N, R85W. Cobbles and pebbles of emerald-green jade were found in Quaternary lag gravels and in the Split Rock Formation (Tertiary) southwest of Rattlesnake Hills near Black Rock Mountain (Love, 1970).

Tin Cup district

One of the most productive regions for jade is north and northwest of Jeffrey City in the Tin Cup Mountain and Graham Ranch areas. The Tin Cup district is underlain by amphibolite-grade Archean gneiss, schist, and amphibolite intruded by granite. In addition to jade, some ruby, sapphire, jasper, minor secondary copper, and some massive sulfide (pyrite) have been found in the district (**Figure 30**) (Hausel, 1996c).

The district is accessible from the Graham Ranch road turnoff 4 miles west of Jeffrey City along Highway 287. Another access route exists along the old Western Nuclear uranium mill road north of Jeffrey City. About 3 miles north on this road, a jeep trail near the reclaimed mill site continues west to the district. *Recommended maps: (1) U.S. Geological Survey topographic map of the Rattlesnake Hills 1:100,000-scale Quadrangle; and (2) U.S. Geological Survey topographic maps of the Graham Ranch, Tin Cup Mountain, Stampede Meadow, and Muskrat Basin 1:24,000-scale quadrangles. Because*

Figure 61. Generalized geologic map of the Rattlesnake Hills (from Hausel, 1997).

the area includes a mixture of private, state, and public land (BLM), we also recommend the 1:100,000-scale land status map of the Rattlesnake Hills.

Green Giant (Abernathy). A pit located in E/2 E/2 section 13, T30N, R93W, and W/2 W/2 section 18, T30N, R92W, was dug in quartzofeldspathic gneiss revealing greenish-black nephrite in a northwesterly-trending shear zone surrounded by masses of epidotite and epidotized amphibolite within the gneiss (Sherer, 1969). Samples of the jade consisted of wedges and slivers of translucent to opaque, dark-green to apple-green, nephrite jade. Some of the jade has a distinct greenish-white rind **(Figure 62, Plate 7)** (W. Dan Hausel, personal field notes, 1995).

Imperial Jade prospect. Snowflake jade was found in SW SE section 2, T30N, R93W. This jade is a green nephrite with white flecks. The flecks are formed of actinolite, quartz, epidote-clinozoisite, sphene, garnet, chlorite, and plagioclase that is pervasively altered to white mica. In addition to the snowflake jade, some olive-green jade was found in the cores of some quartz veins and pods.

The snowflake jade occurs in close association with amphibolite inclusions dominated by fibrous actinolite. Where the nephrite is found, the host rock is altered, producing a bleached, white rock with some pistachio-green epidote-clinozoisite and pink to white clots of zoisite and white mica (Sherer, 1969).

The jade was found in hydrothermally altered mafic inclusions in leucocratic granite. Collectors have depleted most of the jade from this prospect, although undiscovered occurrences may exist at shallow depth (W. Dan Hausel, personal field notes, 1995).

OHL Red #1 (Lucky Strike). Hagner (1945) reported that olive-green jade was found on the Lucky Strike claim in the W/2 section 20, T30N, R92W. It was later restaked and named the OHL Red #1 by Robert Odell of Casper. Field investigations by the Wyoming State Geological Survey showed leucocratic granite-gneiss with foliation striking N35°E and dipping 45°SE. The gneiss contains minor epidotized mafic inclusions, secondary quartz, and some actinolite. One small pocket of jade found immediately northeast of the prospect pit enclosed several prismatic quartz crystals. Locally, some hexagonal psuedomorphs of jade after quartz were also found **(Figure 63, Plate 7)** (W. Dan Hausel, personal field notes, 1995).

Oregon Trail prospect. Several masses of jade were found in the highwall of a prospect pit immediately north of the Sweetwater River in NE NE section 6, T29N, R92W. The typical wallrock alteration assemblages seen in other jade prospects is lacking in this prospect (W. Dan Hausel, personal field notes, 1995).

Radio Tower jade. This occurrence is located in NW SW section 17, T30N, R92W. Dark olive-green nephrite jade, enclosed by a quartz vein, contains euhedral quartz crystals projecting into massive nephrite jade. Some of the quartz contains salients of needle-like fibers of actinolite (Sherer, 1969). Detrital jade was also found and mined from the adjacent alluvium. Only minor amounts of jade could be found in this prospect when examined in 1995 (W. Dan Hausel, personal field notes, 1995).

Rhoads jade pit. Apple-green jade was found in thin dikes cutting granitic pegmatite in SW section 3, T30N, R92W. This is one of the few places in Wyoming where apple-green jade has been found *in situ* (Love, 1970).

School Bus prospect. This occurrence is in SW section 32, T30N, R92W. Small amounts of nephrite jade are exposed in a prospect pit developed in bleached granite. The jade was found adjacent to a large milky quartz pod (W. Dan Hausel, personal field notes, 1995).

E/2 NW section 30, T30N, R92W. Bleached leucocratic granite with a slight purple coloration was found in a worked-out jade prospect. The granite has a pleasing color and may produce an attractive lapidary stone. XRD analysis of the purplish aphanitic groundmass yielded a match for lepidolite, a lithium-bearing mica (Robert W. Gregory, personal communication, 1995).

NE section 30, T30N, R92W. In this prospect pit, prismatic quartz crystals project into nephrite pods hosted by altered gneiss. Other veinlets and pods of jade are found in the pit wall (W. Dan Hausel, personal field notes, 1995).

W/2 section 1, T30N, R93W. A small amount of nephrite jade was found in a veinlet with chlorite and epidote. The vein cuts leucocratic granite. The granite adjacent to the jade displays distinct zones of pink zoisite, pistachio-green epidote, and white feldspar (W. Dan Hausel, personal field notes, 1995).

S/2 SW section 13, T30N, R93W. Jade was found in association with serpentinite in felsic gneiss at this location (W. Dan Hausel, personal field notes, 1995).

SW SW section 13, T30N, R93W. Gray-green and olive-green nephrite occurs as pods and slivers in felsic rock. In the vicinity of the jade, the felsic rocks are bleached white. Adjacent to the jade pods, the rocks are mottled pink and white from secondary clinozoisite and plagioclase (Sherer, 1969).

NW NW section 24, T30N, R93W. Dark, olive-green, schistose nephrite was found in a vein that pinches and swells along strike, and is as much as 10 inches wide. Foliation in the nephrite parallels the vein margins. On both sides of the vein, epidotite and amphibolite occur in felsic country rock. The felsic rock is altered and rich in epidote with plagioclase and actinolite; the feldspar is partially altered to white mica (Sherer, 1969).

Hartville uplift-Guernsey area

Some jade was reportedly found in the Hartville uplift of eastern Wyoming; however, the jade occurrences do not appear to be widespread. *Recommended maps: U.S. Geological Survey topographic maps of the Douglas and Torrington 1:100,000-scale quadrangles.*

Glendo Reservoir. The Eloxite Corporation (1971) reported jade slicks in sections 5, 6, 7, and 8, T30N, R68W, near the northern shore of Glendo Reservoir.

North Platte River area. Jade float was found in a gravel quarry along the North Platte River east of Guernsey in NE SE section 6, T26N, R65W. The sample was verified by XRD (Jay Roberts, personal communication, 1988). The sample was found in river gravels; the original source of the jade is unknown.

Laramie Mountains

Nephrite was reported by Sherer (1969) near the confluence of Rabbit and LaPrele creeks in the Laramie Mountains. These occurrences are associated with orthoamphibolite dikes emplaced in Archean granites and gneisses. Keenan (1964) suggested that alluvium along the Platte River northeast of this area was a potential source for jade float. *Recommended maps: U.S. Geological Survey topographic maps of the Douglas and Laramie Peak 1:100,000-scale quadrangles.*

Crazy Horse Creek. In the NE NW section 13, T29N, R75W (**Figure 64**), prospect pits exposed iron-stained quartz and pods of dark olive-green nephrite in an orthoamphibolite dike. The dike is west of Crazy Horse Creek (Sherer, 1969).

LaPrele Reservoir area. An area west of LaPrele Reservoir (sections 19, 29, and 30, T32N, R73W; and sections 24 and 25, T32N, R74W) was reported to contain *in situ* nephrite jade (Bob Berry, personal communication to Sutherland, 1988).

Rabbit Creek. In the NW NW section 5, T29N, R74W, a 30-foot-deep shaft was sunk on jade (Sherer, 1969), but the shaft was later buried.

Rabbit and Porcupine creeks. This occurrence is located between Rabbit and Porcupine creeks in SW NW section 19, T29N, R74W (**Figure 64**).

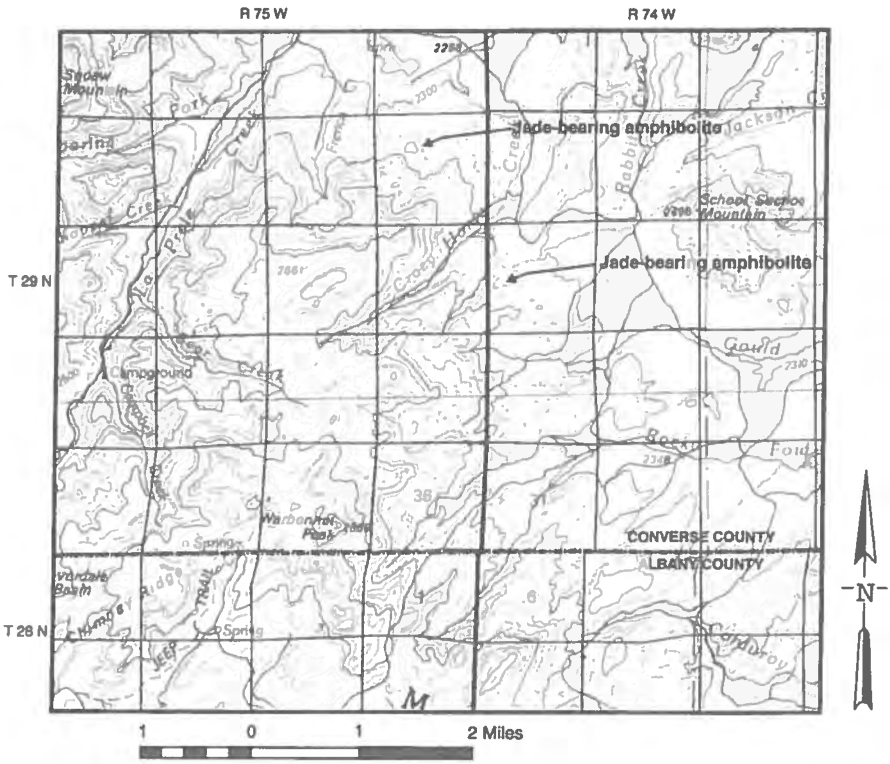


Figure 64. Location map of beryl and jade occurrences in the Warbonnet Peak-Rabbit Creek-Crazy Horse Creek area, adapted from U.S. Geological Survey 1:100,000-scale topographic map of the Laramie Peak Quadrangle.

Greenish-black nephrite has been reported in pods separated from altered orthoamphibolite by a zone of extensively altered rock composed of actinolite, epidote, biotite, and limonite. Part of the nephrite has been altered to a soft, buff-colored, actinolite schist.

Another nephrite prospect lies about 200 feet northeast of the previous occurrence along the orthoamphibolite dike. In this prospect, dark-green nephrite lenses are reported in an altered zone of epidote with limonite psuedomorphs after pyrite (Sherer, 1969).

Rawlins uplift-Sage Creek Basin

Nephrite float from an unknown source has been reported from two localities in the Rawlins uplift-Sage Creek Basin area. *Recommended map: U.S. Geological Survey topographic map of the Rawlins 1:100,000-scale Quadrangle.*

Rawlins golf course. Osterwald and others (1966) reported nephrite jade float on the Rawlins golf course (T21N, R87W).

Sage Creek Basin. This area is located south of Rawlins and west of Saratoga in the vicinity of Ts18 and 19N, Rs86 and 87W. Good-quality black jade float was found here (Ralph Platt, personal communication to Sutherland, 1989).

Seminoe Mountains

The Precambrian core of the Seminoe Mountains consists of an Archean greenstone belt fragment intruded by granite (**Figure 49**). The district is principally known for gold, although minor amounts of jade have been reported from the mountains as well as from the alluvium along the North Platte River.

Dark-green jade was reported in pediment gravels on the north side of the Ferris and Seminoe mountains (Love, 1970; Sutherland, 1990). Some float jade has also been found in Shirley Basin east of the Seminoe Mountains (Sherer, 1969). Bishop (1964) reported jade outcrops associated with Archean amphibolite dikes in the Sunday Morning Creek Metavolcanics.

Float jade has also been reported east of Seminoe Dam. Some of the best black jade found in the state was reported from the Kortes Dam area and farther north near Pathfinder Reservoir (McFall, 1976). *Recommended maps: U.S. Geological Survey topographic maps of the Shirley Basin and Baroil 1:100,000-scale quadrangles.*

Long Creek-Sunday Morning Creek area. This area is in sections 23, 26, 27, and 28, T26N, R85W. Bishop (1964) reported actinoliferous amphibolite occurred as jade-like dikes in contact with amphibolite schist in this area. No jade was found in this area by Hausel (1994b), although the region contains metakomatiites with tremolite and actinolite.

Pathfinder Dam. Jade was reported in section 24, T29N, R84W, in the Pathfinder Dam area (Osterwald and others, 1966).

Sage Creek. Some jade was reported north of the Seminoe Mountains and east of the Miracle Mile along the North Platte River in the NE SE section 12, T26N, R84W. The jade occurs in a quartz diorite dike in quartzofeldspathic gneiss. The jade is dark, olive-green nephrite, and occurs in a pod-like body with quartz (Bishop, 1964; Sherer, 1969).

Seminoe Mountains. Bishop (1964) reported wind-faceted and angular boulders of both black and green nephrite jade in the pediment gravels along the north flank of the Seminoe Mountains in T26N, Rs84 and 85W. Much of the jade exhibited a distinct reddish-brown rind.

Wind River Basin

Nephrite float is reported in the Wind River Basin. *Recommended maps: U.S. Geological Survey topographic maps of the Lysite and Rattlesnake Hills 1:100,000-scale quadrangles.*

Lysite area. Black, dark-green, and gray-green jade float was reported in the Reservoir Creek area south of Lysite and north of Moneta (Rohn, 1986). The area is in sections 30 and 31, T38N, R90W; and sections 35 and 36, T38N, R91W.

Moneta area. Light-green jade was reportedly found at Moneta (section 23, T37N, R91W) along U.S. Highway 20/26 (Osterwald and others, 1966).

Muskrat Creek area. Boulders of dark-green and black nephrite were found in section 20, T32N, R91W, in the Wind River Formation along the southwestern margin of the Gas Hills uranium district. Some dark-red rubies were also reported at this locality in the southern Wind River Basin (Love, 1970).

Wind River Range

There are unverified reports of nephrite jade occurrences in this area. Some reported jade from this region may have been massive amphibolite and serpentinite (W. Dan Hausel, personal field notes, 1979). *Recommended maps: U.S. Geological Survey topographic maps of the Ramshorn and Pinedale 1:100,000-scale quadrangles.*

Dubois area. Olive-green jade was reported in the area northeast of Dubois in T43N, R104W (Cheyenne Gem and Mineral Society, 1965; Osterwald and others, 1966).

Prospect Mountains. Low-quality black nephrite jade, known as the Game Warden jade, was reported in the Prospect Mountains area (sections 3, 4, 9, and 10, T29N, R103W, and sections 27, 28, 33, and 34, T30N, R103W). Samples collected from this region contained no detectable jade (W. Dan Hausel, personal field notes, 1995)

Lewiston (South Pass) region

Jade was reportedly found in place near the Sweetwater River in the general vicinity of the Lewiston district at the southern tip of the Wind River Range. Some serpentinites have been mistaken for jade in this region in past years. *Recommended map: U.S. Geological Survey topographic map of the South Pass 1:100,000-scale Quadrangle.*

Silver Creek Reservoir area. A boulder of apple-green jade was cut by the Carter CH14 drill hole in the NW section 24, T29N, R97W, at a depth of about 400 feet (Love, 1970).

T27N, R97W. Black jade float was reported in this area by the Cheyenne Gem and Mineral Society (1965).

KYANITE (see ANDALUSITE, KYANITE, SILLIMANITE, STAUROLITE)

Plates 1-13.

Figure 4. Massive green sillimanite crystals collected in the Barlow Gap region.

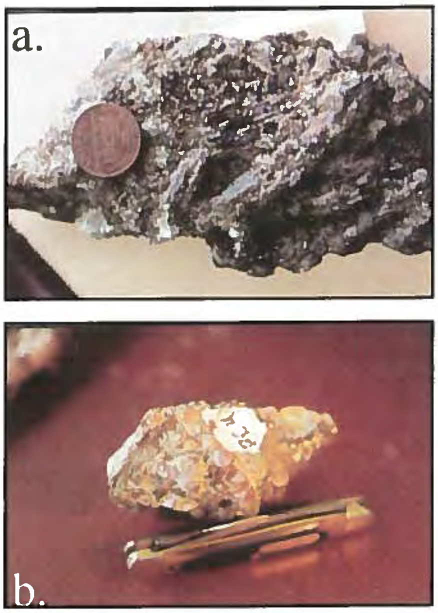


Figure 6. (a) Blue, prismatic, kyanite blades with reddish corundum are found in mica schist, and (b) translucent, pink "ruby" in mica schist at Palmer Canyon.

Figure 9. Bluish-green fluorapatite in a white, quartz-rich matrix, Granite Mountains.

Figure 10. Light-blue, transparent to translucent, tabular barite crystals from the Mine Hills, Shirley Basin.

Figure 12. Light yellow-green opaque, hexagonal beryl from a pegmatite at Casper Mountain.

Plate 1

Figure 19. Sand-calcite crystals from Goshen Hole (specimen donated by Norma Beers).

Figure 20. Hartville Mexican onyx.

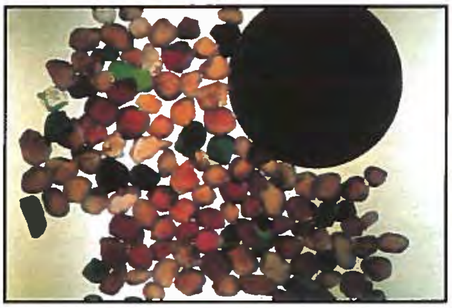


Figure 22. Kimberlitic indicator minerals collected from anthills in the Butcherknife Draw area.

Figure 23. Kimberlitic indicator minerals recovered from the Cedar Mountain pipes (photograph by Richard E. Kucera).

Figure 25. Kimberlite from Iron Mountain, with reddish pyrope garnet and gray, metallic picroilmenite megacryst.

Plate 2

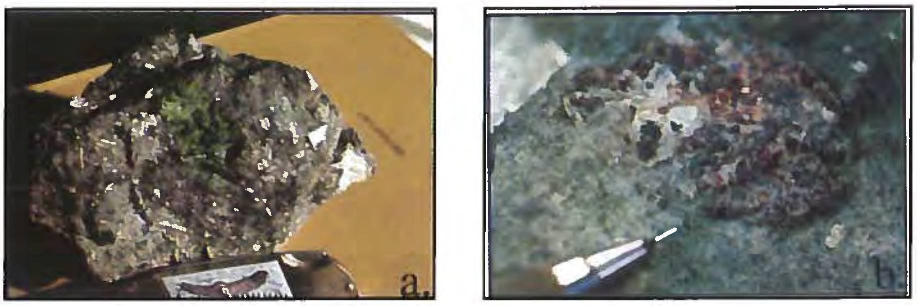


Figure 27. (a) Kimberlite with large chrome diopside megacryst, and (b) kimberlite with large pyrope garnet megacryst, both from the Sloan property, State Line district, Colorado.

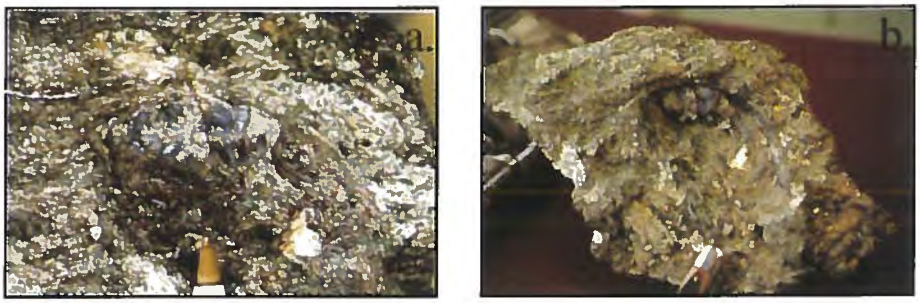


Figure 28. (a) Sapphire-blue iolite collected from the Palmer Canyon deposit, and (b) the same crystal is seen in a depression that suggests the crystal was at one time much larger.

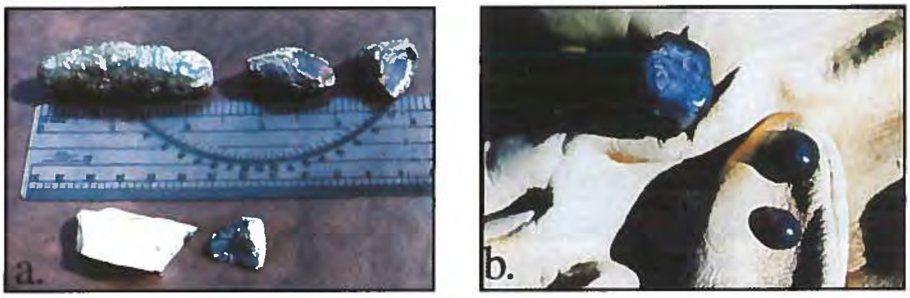


Figure 29. (a) Hexagonal, barrel-shaped rubies from the Tin Cup district, and (b) attractive polished "ruby" cabochons from the Red Dwarf prospect (photographs by Robert Odell).

Plate 3

Figure 32. Ruby porphyroblast collected from the Red Dwarf deposit by Eric Hausel (photograph by Robert Odell).

Figure 33. A faceted diamond from the Green River Basin. This stone was apparently recovered from the Green River Basin, verified by a gemologist, and later faceted (photograph by Dave Freeman).

Figure 34. A beautiful, flawless, uncut 14.2-carat octahedron diamond from the Kelsey Lake mine, Colorado (photograph courtesy of Howard G. Coopersmith and Redaurum Ltd.).

Figure 35. A 16.8-caret fancy canary-yellow gemstone cut from a 28.18-carat diamond from the Kelsey Lake mine (photograph courtesy of the Denver Post).

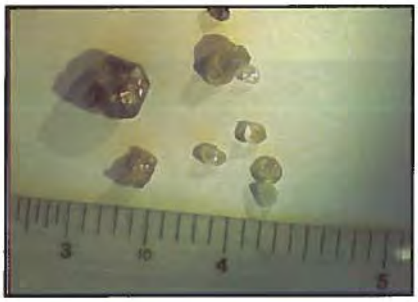


Figure 36. An assortment of gem-quality diamonds from the Sloan 2 kimberlite, Colorado. The largest diamond in the photograph weighed 5.51 carats (Bernhard Free, personal communication, 1996).

Figure 37. An assortment of gem and industrial diamonds from the Schaffer group of kimberlites. The largest diamond in the photograph is a high-quality 0.86-carat gemstone.

Plate 4

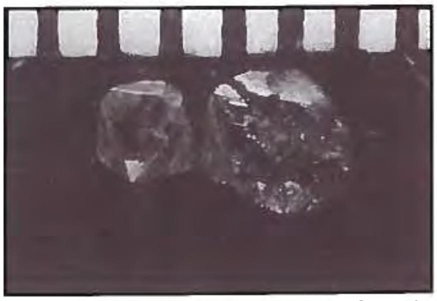


Figure 38. Boden placer diamonds from the gold prospect on Cortez Creek, Medicine Bow Mountains (Paul Boden, personal communication, 1977). The larger diamond weighed 0.1 carat and the smaller diamond weighed 0.03 carat; scale is in millimeters.

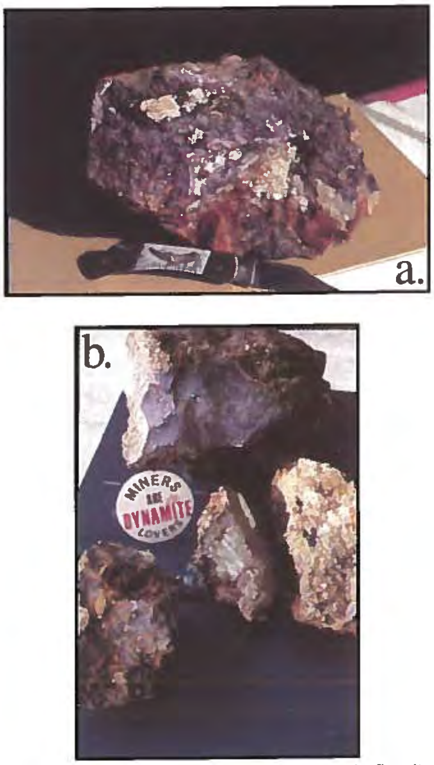


Figure 41. (a) Massive to crystalline purple fluorite replacing limestone with numerous small flourite cubes, and (b) a variety of fluorite-bearing samples from the Bear Lodge Mountains.

Figure 43. Trapezohedral garnet porphyroblasts in mica schist.

Figure 44. Large dodecahedral chlorite-biotite pseudomorph after garnet from the Sierra Madre. Sample courtesy of Mel and Grace Dyck.

Figure 45. Large pyrope-almandine garnet megacrysts collected from the State Line district.

Plate 5

Figure 46. An assortment of gem-quality pyrope garnets and chromian diopsides collected from ant-hills in the Green River Basin, with a faceted pyrope in the center (sample courtesy of Dave Freeman).

Figure 48. Gold nuggets recovered from the Douglas Creek district (photograph by Paul Allred).

Figure 50. A gold nugget from the South Pass area weighs nearly 7.5 ounces (photograph by Dave Freeman).

Figure 54. The Rhodes 3200-pound boulder of apple green jade found near Crooks Gap. This boulder is about 4 feet long and about 2 feet wide (photograph by J. David Love).

Figure 55. Wind- and sand-polished apple-green jade boulder weighing about 350 pounds. The specimen is of museum quality and was found on the Rhoads claims on the north side of Green Mountain sometime between 1932 and 1935. The asking price for this boulder was $40,000 in June, 1999. Photograph courtesy of Dave Freeman, Millennium Jade of Wyoming, June, 1999.

Plate 6

Figure 56. A variety of Wyoming jade specimens include: (a) the Bull Canyon black block (the squared off block rock in upper left); (b) a 14-pound chunk of apple-green (the triangular block, left center), about 9 inches wide at its base; (c) a unique gray-black mottled specimen (irregular stone between triangular green block and the square green block); and (d) a slice of the Edwards Black boulder (black specimen on extreme right). Photograph courtesy of Dave Freeman, Millennium Jade of Wyoming, June, 1999.

Figure 57. Geologist J. David Love examining a 218-pound apple slick jade boulder found sometime between 1932 and 1935 on the Rhoads claims on the north flank of Green Mountain near Jeffrey City. Photograph courtesy of Dave Freeman, Millennium Jade of Wyoming, June, 1999.

Figure 58. Geologist J. David Love examining some jade boulders of "very good quality" from the Rhoads claims near Jeffery City. Photograph courtesy of Dave Freeman, Millennium Jade of Wyoming, June, 1999.

Figure 62. Jade slick in tremolite schist with associated white rind. Collected from the Jeffrey City region.

Figure 63. Hexagonal psuedomorphs of nephrite jade after quartz. The jade has completely replaced the former quartz crystals.

Plate 7

Figure 65. Polished labradorite collected from the Shanton deposit in the Laramie anorthosite complex.

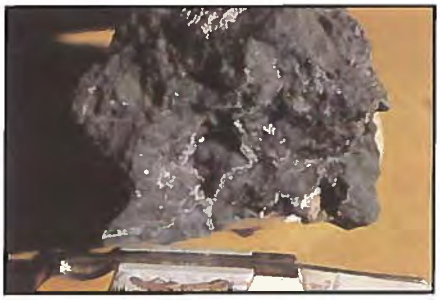


Figure 66. Botryoidal manganite and pyrolusite mammillary crusts partially replacing chert and sandstone in the Casper Formation.

Figure 67. Opalized quartz collected from the Sierra Madre.

Figure 68. Beautiful specimen of malachite and secondary quartz on limestone.

Figure 69. Sample of pyritized quartz with small pyrite cubes from the Lost Muffler prospect, Rattlesnake Hills.

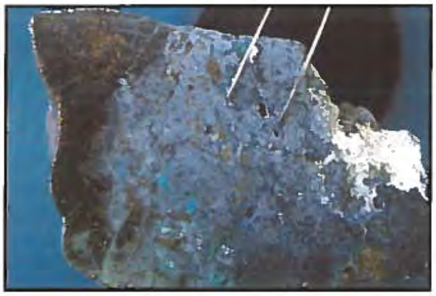


Figure 74. Polished specular hematite and chalcopyrite from the Charter Oak mine.

Plate 8

Figure 75. The Ferris-Haggarty mine, Garnd Encampment district, Sierra Madre. (a) Cupriferous breccia, (b) Robert W. Gregory inside the mine workings, and (c) ore zone consisting of sheared cupriferous metaconglomerate exposed in the production tunnel.

Figure 76. Massive pyrite, calcite, and quartz vein from the Snowbird mine, South Pass.

Figure 78. Olivine xenocryst in lamproite from Black Rock.

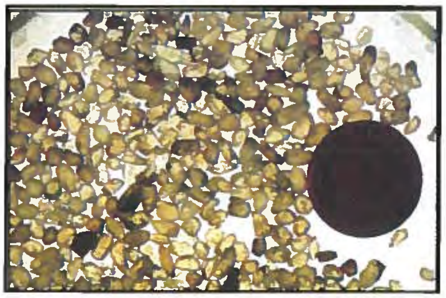


Figure 79. Some of the peridot found in anthills in the northeastern Leucite Hills. Much of the peridot is a beautiful olive-green, with uncommon reddish peridot. Note the crystals' transparency with little evidence of cleavage.

Plate 9

Figure 82. Sweetwater moss agates from the J. David Love collection (photography by Sutherland).

Figure 83. A variety of agates and jaspers are found in the Rattlesnake Hills. Attractive, light-blue botryoidal chalcedony fills an open space in a silicified sandstone (larger specimen), and to the left is a typical, yellow-to-red jasper found along some of the exhalitive veins in the center of the district.

Figure 85. Sample of Blue Forest agatized wood from the Wayne Sutherland collection.

Figure 86. Large concretions (geyser rock) from the Granger area in the Green River Basin. (a, above) Large concretion showing concentric zoning, and (b, below) samples of quartz-calcite crystals recovered from the concretions (photographs by Carolyn Jones, 1996).

Figure 87. Banded jasperoid from Quaking Asp Mountain.

Plate 10

Figure 89. Banded fortification agate from the Hartville uplift (photograph by Sutherland). Specimen is about 3 inches across.

Figure 90. Youngite showing drusy quartz enclosing breccia fragments of Guernsey Formation limestone (sample from Norma Beers).

Figure 91. Light-purple to lavender, botryoidal Pinto agate. Sample from Norma Beers.

Figure 92. Polished jasperized banded iron formation cobble (left) with distinctly folded banded iron formation (right).

Figure 93. Polished and unpolished Twin Creek jasper from the Hank Hudspeth collection.

Figure 94. Komatiite with turkey-track tecture from the South Pass region (left), and peanut schist (right) with peanut-like porphyroblasts of andalusite(?), South Pass.

Plate 11

Figure 95. Leopard rock from the Lewiston district, South Pass region (right) and Seminoe Mountains (left).

Figure 96. Orbicular granodiorite from the Ferris Mountains.

Figure 97. Porphyroblastic mica schist from Palmer Canyon showing numerous red rubies in chlorite-biotite schist.

Figure 98. Some varieties of serpentinite found in Wyoming. These samples are from South Pass, Seminoe Mountains, and the Tin Cup district.

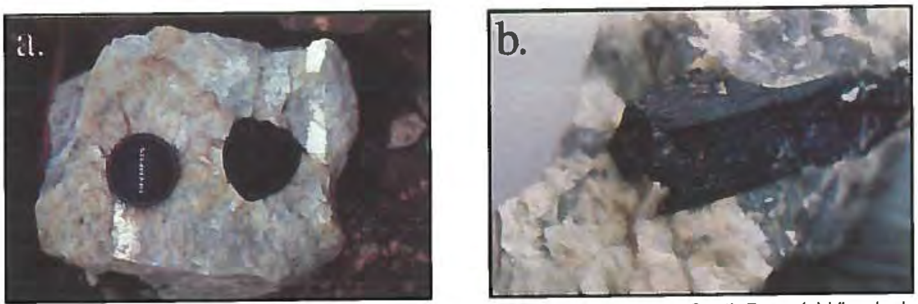


Figure 99. Black schorl tourmaline from pegmatite in the Anderson Ridge area, South Pass. (a) View looking down c-axis of the tourmaline showing typical triangular cross-section, and (b) side view of tourmaline showing prismatic habit.

Plate 12

Figure 100. An assortment of rocks and minerals collected in Wyoming. Numbered samples displayed in photograph are: 1) Blue botryoidal chalcedony-bearing sandstone, Rattlesnake Hills; 2) Massive fuchsite replacement of purple-red corundum, Red Dwarf ruby deposit, Granite Mountains; 3) Blue Forest petrified wood, Farson; 4) Blue barite, Mine Hills, Shirley Basin; 5) Youngite, Hartville uplift; 6) Jasper, Tin Cup district, Granite Mountains; 7) Prismatic quartz crystal, State Line district, Laramie Mountains; 8) Prismatic corundum, Laramie Mountains; 9) Corundum, Red Dwarf deposit, Granite Mountains; 10) Slater agate, Denver-Julesburg Basin; 11) Malachite in metaconglomerate, Ferris-Haggarty mine, Sierra Madre; 12) Labradorite, Sybille Canyon, Laramie Mountains; 13) Pyrope garnets, Butcherknife Draw, Green River Basin; 14) Native gold, Douglas Creek, Medicine Bow Mountains; 15) Tourmaline, location unknown; 16) Peridot, Leucite Hills, Rock Springs uplift; 17) Diamonds, Schaffer kimberlite complex, State Line district, Laramie Mountains; 18 Chromian diopside, Schaffer kimberlite complex, State Line district, Laramie Mountains; 19) Onyx (jasperoid), Quaking Asp Mountain, Green River Basin; 20) Goniobasis agate, Red desert; 21) Bornite-malachite copper ore, Ferris-Haggarty mine, Sierra Madre; and 22) Massive chalcopyrite, Ferris-Haggarty mine, Sierra Madre.

Plate 13

LABRADORITE

Labradorite, a plagioclase feldspar with the general composition [Na, Ca (Al,Si) $AlSi_2O_8$], usually occurs as a gray or dark-brown to dark-gray nondescript triclinic mineral with polysynthetic twinning. Cleavage occurs in two directions at nearly right angles. In Wyoming, labradorite is reported northeast of Laramie in the anorthosite batholith of the Laramie Mountains. Labradorite has a hardness from 5 to 6 and a specific gravity between 2.6 and 2.75.

Some specimens of labradorite from the Laramie anorthosite complex show brilliant displays of blue and red color known as *fire*, or *iridescence*, similar to some opals (**Figure 65, Plate 8**). The iridescence results from light reflecting along thin exsolution lamellae comprised of different mineral inclusions within the feldspar. When some specimens of labradorite are rotated in the sunlight, colors of blue, green, yellow, and red play across the basal [m{010}] cleavage, or along polished planes nearly parallel to this cleavage. Such specimens with brilliant fire are generally sought by mineral collectors, and will produce beautiful decorative stone, museum specimens, and some gems.

In addition to labradorite, a few other feldspars have been used as gemstones. These include moonstone, peristerite, adventurine, sunstone, and amazonite. Moonstone, in particular, can produce attractive gems when found as translucent varieties of high-temperature orthoclase, known as andularia. Some varieties of andularia exhibit a bluish sheen, known as schiller or adularescence, which moves across the surface of the stone. The sheen is the result of the interference of light reflected from submicroscopic intergrowths of orthoclase and albite.

Another rare gemstone is yellow orthoclase, which is sometimes faceted. But these are too soft (hardness of 6) for typical day-to-day wear as gemstones. Amazonite, a variety of microcline feldspar, generally is bright green to sometimes blue-green. It is frequently seen in carvings and as cabochons that are used in pendants and brooches. The green color is due to vacancies in the crystal lattice resulting from the substitution of lead for potassium (Hurlbut and Switzer, 1979). The only report of amazonite in Wyoming is from the Laramie Mountains in T22N, R69W, on the Whitetail Ranch. No specific details are available.

The only gem varieties of feldspar that have been reported in Wyoming are some specimens of labradorite found in the Sybille Creek area of the Laramie Mountains.

Sheep Rock area. Specimens of labradorite can be found along State Highway 34 about 4 miles southwest of the Sybille Canyon State Game Reserve in sections 3, 9, and 10, T20N, R72W. Some bulldozed areas along the edge of the highway were cut during exploration for labradorite. Good labradorite specimens can also be found in the nearby drainages. Much of the material has a brown iron stain, but the color on a fresh break can be gray or blue. Some excellent samples of labradorite have also been found in the road bed material of Albany County 12 along Grant Creek (Norma Beers and Letty Heumier, personal communication, 1999). *Recommended map: U.S. Geological Survey topographic map of the Sheep Rock 1:24,000-scale Quadrangle.*

MANGANITE–PSILOMELANE

Manganite [$MnO(OH)$] forms black submetallic minerals that are often deeply striated and produce a dark reddish-brown streak. Crystals have perfect side cleavage, fair prismatic and basal cleavage, and often alter to pyrolusite, a soft manganese oxide that produces a black streak. Manganite has a hardness of 4, and a relatively high specific gravity of 4.33.

Psilomelane [$BaMnMn_8O_{16}(OH)_4$] is a barium-bearing manganese oxide. It often occurs as black, botryoidal or stalactitic aggregates or earthy masses that are iron black. Psilomelane will produce a black to brownish-black streak. This mineral has a hardness of 5 to 6 and a specific gravity of 4.7. It is often associated with barite, goethite, pyrolusite, and/or calcite. Neither manganite nor psilomelane produces gemstones, but specimens collected in the Mine Hills of the Shirley Basin can produce attractive museum variety samples (see also **BARITE**).

Mine Hills. Barite is found with calcite in vugs that occur in sandstone of the Casper Formation in section 10, T26N, R75W, (**Figure 11**). The barite is associated with manganese and jasper (**Figure 66, Plate 8**). A small tonnage of manganite and pyrolusite was mined from two chert beds in the Casper Formation from this area. The manganese occurs as oxides in mammillary crusts and nodular aggregates partially replacing chert and sandstone. Cavities in the chert contain small quartz crystals on layers of manganite. Botryoidal clusters of wedge-shaped manganite and tabular barite crystals line some of the cavities. *Recommended map: U.S. Geological Survey topographic map of the Laramie Peak 1:100,000-scale Quadrangle.*

OPAL

Opal, a macroscopically amorphous hydrous silica dioxide ($SiO_2 \cdot nH_2O$), may contain as much as 10% water. Because of the water content, the luster of opal will vary from glassy to resinous, and occasionally pearly. Some opals will also display a *fire* or rainbow play of colors in sunlight, making the mineral very attractive to collectors. Some opals are also cut into cabocons and used in rings and brooches.

Opal has a hardness ranging from 5.5 to 6.5, is brittle, and will produce conchoidal fracture when broken. Opal is relatively sensitive to abrupt changes in temperature, which can cause the mineral to fracture. Excessive heat can drive off the loosely held water in opal, and destroy the fire.

Opal can be distinguished from chalcedony by both its lower specific gravity and its distinctive luster. According to Sinkankas (1959) opal has a relatively low specific gravity, which varies from 1.9 to 2.2. Its refractive index varies from 1.444 to 1.464, showing only single refraction with no dichroism. Opals range from opaque, translucent to almost transparent, and may be colorless, white, cream, yellow, orange, red, green, pink, brown, and even black, such as the extraordinary Australian black opals.

Precious opal can be considered a gemstone because of its play of colors, which sometimes is extraordinarily intense and brilliant. The color plays, which are usually blues, reds, and yellows, are found only in the precious opal. Sometimes this play of colors will produce an attractive fire opal with bright red to yellow colors.

Opal forms by precipitation from silica-saturated waters associated with volcanic activity including geysers and hot springs. Opal occurs as fissure and void fillings, forming veins and seams in some volcanic rocks and geyserites. Opal may also replace wood and produce opalized wood.

Even though it has been reported in the Yellowstone and Absaroka volcanic terranes, opal is not common in Wyoming. According to Sinkankas (1959), some siliceous sinters and geyserites which form the terraces and cones of some geysers in Yellowstone National Park may contain opal. Seams of opal have also been reported on the north flank of Mount Washburn and opalized wood has been found in several areas in Yellowstone. [Remember that it is illegal to collect in national parks.] Some specimens of fire opal have also been found in the Absaroka Mountains along the eastern border of Yellowstone (J. David Love, personal communication to Sutherland, 1989).

Opal has been found associated with Tertiary tuffaceous sedimentary rocks of the White River and Wind River formations in Wyoming. Some common opal is reported in the White River Formation in the northern Hartville uplift in eastern Wyoming (Mueller, 1976), and some has been reported in tuffaceous rocks of the White River Formation along Beaver Divide in central Wyoming (J. David Love, personal communication to Sutherland, 1989).

White opal was once found in quantity near Pathfinder Reservoir in central Wyoming (Ralph Platt, personal communication to Sutherland, 1989). Osterwald and others (1966) described some other opal localities: along the Sweetwater River in the Granite Mountains; Sage Hen Creek and Agate Lake in central Wyoming; and near Jackson Lake in northwestern Wyoming. Common opal was also reported in the Cyclone Ridge area of southern Wyoming (Ralph Platt, personal communication to Sutherland, 1989). Some opal concretions have also been reported in Tertiary sedimentary rocks near Smith Creek in Carbon County.

Black Hills

Southeastern Bear Lodge Mountains. According to Chenoweth (1955), a 150-foot-deep shaft sunk adjacent to the Bear Lodge truck trail, 1.5 miles northeast of the intersection with the Warren Peaks road, contained copper minerals associated with light-green and white opal in veinlets. The copper minerals included malachite, iron oxide, cuprite(?), and chrysocolla. These minerals were found as fracture fillings in altered kaolinized porphyritic syenite(?) (see **ORE MINERALS**).

Granite Mountains

Tin Cup district. A prospect pit located along trend between the Sutherland and Red Boy mines in the S/2 S/2 SE section 25, T31N, R93W, contained dump material that included opalized quartz, quartz, and jasperoidal hematite (W. Dan Hausel, personal field notes, 1995). *Recommended map: U.S. Geological Survey topographic map of the Rattlesnake Hills 1:100,000-scale Quadrangle.*

Green River Basin

A group of geographic names which use the term *opal* are found in the western part of the Green River Basin near Hams Fork River east of Kemmerer. These include Opal in section 26, T21N, R114W; Opal Springs in the NE section 21, T21N, R114W; and Opal Bench in the southern part of T22N, Rs112 and 113W. According to Urbanek (1988) these names either originated from the name of a sheepherder's dog, or from a railroad conductor who reported opal in the surrounding hills.

Miscellaneous locations in Wyoming

Pathfinder Reservoir. Clear moss opal and common white opal are reported along the western margin of Pathfinder Reservoir in section 32, T27N, R84W. This occurrence is associated with white tuffaceous sandstone of the Split Rock Formation(?) (Miocene). Common white opal is also reported from the same rock unit east of Pathfinder Reservoir (Bohn Dunbar, personal communication to Sutherland, 1989). *Recommended map: U.S. Geological Survey topographic map of the Shirley Basin 1:100,000-scale Quadrangle.*

Shawnee Creek area. This occurrence is located east of Douglas in section 28, T32N, R69W. J.W. Gruner (unpublished field notes, University of Minnesota, 1955) and Gruner and others (1956) reported opal, quartz, and chalcedony in tuffaceous silty rocks of the White River Formation (Oligocene). The opal, quartz, and chalcedony occur in conjunction with a series of northeast-trending fault zones. These zones are silicified, form discontinuous sharp ridges up to 30 feet wide, and are found throughout the south half of the township. *Recommended map: U.S. Geological Survey topographic map of the Douglas 1:100,000-scale Quadrangle.*

Wicker-Baldwin property. This occurrence is located in section 16, T42N, R69W. Gruner and others (1956) mentioned that opal occurred in association with uranium in the Lower Cretaceous Fall River Formation. *Recommended map: U.S. Geological Survey topographic map of the Reno Junction 1:100,000-scale Quadrangle.*

Sierra Madre

Hog Park. In NW section 2, T12N, R85W, opal(?) associated with a pod of barite (see **BARITE**) was reported along the northern edge of a shear zone in contact with red quartz monzonite. According to Merry (1963), the deposit is 40 feet wide and 300 feet long (**Figure 67, Plate 8**). *Recommended map: U.S. Geological Survey topographic map of the Saratoga 1:100,000-scale Quadrangle.*

Wind River Basin

Two opal occurrences are described for the Gas Hills district. *Recommended map: U.S. Geological Survey topographic map of the Rattlesnake Hills 1:100,000-scale Quadrangle.*

Gas Hills. Opal with a trace of uranium was reported in the Vitro Uranium Company open pit (section 26, T33N, R90W) in the Gas Hill uranium district. The opal occurs in the middle to upper Eocene Wind River Formation (Gruner and others, 1956).

Lucky Mac camp. Opal "sulfogel" was reported with uranium at the Lucky Mac property (section 23, T33N, R90W) (Gruner and others, 1956).

ORE MINERALS

Ore minerals include a variety of sulfides, oxides, carbonates, and related minerals, and are found in several of the state's historical mining districts. Many mines in these districts extracted metals from the ores sometime in the past; most still have ore minerals and related ore specimens on the old mine dumps. These materials may provide attractive and instructive specimens, and a few may be considered semi-precious gemstones.

Although many ore minerals have been found in Wyoming, only those deposits where attractive specimens or unique minerals have been found are described here. In addition to the collecting sites described in this section, there are dozens of other properties with ore minerals that are described in Hausel (1989, 1997).

Anglesite ($PbSO_4$)

A soft [hardness (H)=2.5 to 3], heavy [specific gravity (SG)=6.38], white to gray secondary metallic mineral, anglesite is often formed by the weathering and replacement of galena. Massive varieties have a dull luster; tabular and prismatic crystals (orthorhombic) have a resinous luster. Anglesite also occurs in light-gray masses with concentric banding.

Argentite (Ag_2S)

This mineral is also known as silver glance. A soft (H=2 to 2.5), heavy (SG=7.2 to 7.4), sectile, dark lead-gray (tarnishes black) mineral with metallic luster and shiny lead-gray streak, argentite commonly occurs in groups of distorted isometric crystals (Vanders and Kerr, 1967).

Arsenopyrite (FeAsS)

This is a hard (H=5.5 to 6), metallic, silver-gray mineral often associated with lemon-yellow to light, yellowish-green scorodite. Much arsenopyrite found in Wyoming occurs as granular masses, but it may also occur as tiny, striated crystals with rhombic cross-sections. Arsenopyrite produces a garlic (arsenic) odor when struck by a hammer.

Azurite [$Cu_3(CO_3)_2(OH)_2$]

Azurite is a blue copper carbonate that is invariably associated with malachite, a green copper carbonate. Most azurite found in Wyoming occurs as opaque, azurite-blue masses and stains in copper-bearing schists, veins, and volcanic rocks, and less often as botryoidal coatings. Rarely, the mineral is found as well-formed monoclinic crystals in vugs. It has one good cleavage, a hardness of 3.5 to 4, and specific gravity of 3.77. It produces a blue streak, reacts with dilute hydrochloric acid, and like most copper carbonates and oxides, it will partially replace a weathered rock hammer with native copper when the hammer is rubbed into the mineral wetted with dilute hydrochloric acid.

Bornite (Cu_5FeS_4)

Bornite is also known as "peacock ore" due to its distinctive reddish-bronze, iridescent blue and purple color. It is a relatively soft (H=3), brittle, metallic, reddish-bronze mineral that tarnishes to iridescent blue and purple. It has a gray-black streak and is usually massive. The mineral is often found with chalcopyrite and chalcocite.

Bournonite ($CuPbSbS_3$)

Bournonite is also known as "cog-wheel ore." Uncommon in Wyoming, but when found is a soft (H=2.5 to 3), brittle, steel-gray to iron-black, heavy (SG=5.83), metallic mineral that may produce twinned crystals with a distinctive cog-wheel shape. It has three directions of cleavage.

Cerargyrite (AgCl)

Also know as "horn silver," this is a soft, sectile, translucent, massive gray to greenish-gray mineral with bright, waxy, or horn-like luster. It also occurs as crusts and is rare in Wyoming.

Cerussite ($PbCO_3$)

Cerussite is a heavy (SG=6.55), colorless or white mineral with brilliant luster that forms intergrowths of slender, twinned crystals with a grid-like pattern.

Chalcocite (Cu_2S)

Also known as "copper glance," chalcocite is a soft (H=2.5 to 3), subsectile, heavy (SG=5.5 to 5.8), black to lead-gray massive mineral that is often coated with a thin film of green malachite. The mineral yields a shining dark, lead-gray streak.

Chalcopyrite ($CuFeS_2$)

Chalcopyrite is a brittle, deep golden-bronze metallic mineral often with an iridescent tarnish. It yields a greenish-black streak, and is typically found in massive form.

Chrysocolla ($CuSiO_3 \cdot H_2O$)

Chrysocolla is a massive, compact, blue, copper silicate that is too soft (H=2 to 4) for use as a gemstone. However, some specimens mixed with quartz or chalcedony are used in jewelry because the quartz increases the durability of the stone. It has a similar appearance to turquoise and variscite, but is of inferior hardness compared to turquoise. Chrysocolla is uncommon in Wyoming.

Covellite (CuS)

A soft (H=1.5 to 2), distinctive indigo-blue metallic mineral usually associated with other copper minerals and pyrite. Covellite occurs in platy masses that split into thin, flexible flakes along a perfect basal cleavage. It produces a lead-gray to black streak.

Cuprite (Cu_2O)

Typically, cuprite is found in soft (H=3.5 to 4), red, earthy masses associated with other copper minerals such as tenorite or malachite. It is also known as "ruby copper." It yields a reddish-brown streak and will partially replace a weathered rock hammer with native copper when the hammer is rubbed into the mineral wetted with dilute hydrochloric acid.

Digenite (Cu_2S)

Digenite is usually a massive, deep blue to black, opaque, submetallic mineral associated with other copper sulfides.

Enargite (Cu_3AsS_4)

A brittle (H=3), iron-black, metallic mineral usually in bladed aggregates or granular masses with a black streak, enargite has perfect prismatic cleavage. The mineral famatinite (Cu_3SbS_4), is the antimony analogue of enargite.

Galena (PbS)

Galena is a lead-gray, soft, metallic mineral with a brilliant luster that has distinctively high heft (SG=7.58). It may be found with either massive or cubic habit and it is easily scratched with a knife (H=2.5).

Hematite (Fe_2O_3)

Hematite usually occurs as dull-red earthy masses, stains, and masses with botryoidal habit, but may be found as hard (H=5.5 to 6.5), steel-gray, metallic masses known as specularite. The mineral will produce a rusty appearing, dark-red to reddish-brown streak. Some metallic varieties of hematite are fashioned into cabochons.

Hemimorphite [$Zn_4Si_2O_7(OH_2) \cdot H_2O$]

This mineral occurs as white, rounded aggregates that are found in the oxidized zones of zinc deposits.

Idaite (Cu_3FeS_4)

A copper-red to brown metallic mineral, idaite occurs as the lamellar decomposition product of bornite.

Lorandite ($TlAsS_2$)

Lorandite occurs as highly modified tabular to prismatic cochineal-red crystals with perfect cleavage $m\{100\}$, and distinct $m\{001\}$ cleavage.

Lollingite ($FeAs_2$)

A massive (H=5 to 5.5) silver-white to steel-gray metallic mineral, lollingite is often associated with limonite.

Magnetite (Fe_3O_4)

Magnetite is a highly magnetic, black, opaque, metallic mineral occurring in masses or as octahedrons.

Malachite [$Cu_2CO_3(OH)_2$]

A green copper carbonate, malachite is invariably associated with azurite. Malachite occurs in opaque, green masses in copper-bearing schists and veins, and less often as botryoidal coatings or as radiating, silky, fibrous masses. Light- and dark-green concentric color bands are common in malachite. It has a hardness of 3.5 to 4, and produces a green streak. It will react with dilute hydrochloric acid, and partially replace a weathered rock hammer with native copper when the hammer is rubbed into the mineral wetted with dilute hydrochloric acid. The bright green color of malachite makes it attractive as an ornamental stone (**Figure 68, Plate 8**).

Marcasite (FeS_2)

Marcasite is a hard (H=6 to 6.5), brittle, metallic brass-yellow mineral with a greenish-black streak typically occurring in massive form, or as crystals with a cockscomb structure. Its color is whiter than pyrite on a fresh surface.

Molybdenite (MoS_2)

A very soft (H=1 to 1.5), lead-gray, metallic mineral, molybdenite is usually found in foliated or fibrous masses with perfect cleavage. It produces a lead-gray streak and will stain skin gray when rubbed between the fingers.

Native copper (Cu)

Native copper is a soft (H=2.5 to 3), sectile, malleable metal with a copper-red metallic luster that will tarnish to a dull reddish-brown. Native copper has a shining copper streak, and is found in irregular masses and groups of distorted isometric crystals. It is often associated with malachite. This metal is used in ornamental jewelry.

Native gold (Au) (see GOLD)

Native silver (Ag) (see SILVER)

Neotocite ($Mn_2Fe_2Si_4O_{13}\cdot 6H_2O$)

This is a black to brown, amorphous manganese silicate, usually derived from the alteration of rhodonite and other manganese silicates.

Olivenite ($Cu_2AsO_4 \cdot OH$)

Olivenite occurs as globular, reniform, and fibrous masses, or as acicular, prismatic crystals of olive-green color. The mineral yields a similar olive-green streak.

Orpiment (As_2S_3)

Orpiment is rare in Wyoming but it apparently was found with realgar at the New Rambler mine in the Medicine Bow Mountains. Orpiment forms soft, sectile, lemon-yellow foliated masses that split into thin flexible cleavage flakes with resinous luster. Realgar (AsS) is also soft and forms orange-red minerals that alter to orpiment.

Polybasite [$(Ag,Cu)_{16}Sb_2S_{11}$]

Polybasite is a soft (H=2 to 3), iron-black, metallic mineral that occurs either in pseudohexagonal, tabular crystals often with triangular markings on the basal planes or as massive grains. It will produce a black streak.

Proustite (Ag_3AsS_3)

Known as "ruby silver," proustite is a soft (H=2 to 2.5), deep red mineral with a brilliant luster and scarlet streak. The mineral is usually massive, but may occur in aggregates of distorted complex crystals.

Pyrargyrite (Ag_3SbS_3)

Known as dark ruby silver, pyrargyrite is a soft (H=2.5), blackish-red mineral with brilliant almost metallic luster and gives a purplish-red streak. It usually occurs in massive or disseminated grains.

Pyrite (FeS_2)

Pyrite is a hard (H=6 to 6.5), brittle, bright metallic brass-yellow mineral with a greenish-black streak. Often it is massive, but it may occur in striated cubes or pyritohedrons (**Figure 69, Plate 8**). It is often mistaken for gold by laymen and thus has been termed *fool's gold*. However, some pyrites contain gold hidden within the crystal structure. The mineral may host up to 2000 ppm gold within its crystal structure.

Pyrrhotite ($Fe_{1-x}S$)

A brittle, relatively soft (H=3.5 to 4.5), brownish-bronze, metallic mineral that is weakly to strongly magnetic, pyrrhotite has a black streak and typically occurs in granular masses.

Scheelite ($CaWO_4$)

Scheelite is a heavy (SG=6.1), nonmetallic, white mineral that luminesces pale blue under short-wave ultraviolet light. The mineral is very difficult to recognize without a black (ultraviolet) light. It is commonly disseminated or occurs as bipyramidal crystals. Samples from Wyoming consist of disseminated scheelite in quartz veins, granitic veins, and pegmatites.

Smithsonite ($ZnCO_3$)

Smithsonite usually occurs in white, pale-brown, green to blue-green botryoidal masses or in dull honeycombed masses that resemble dry bone.

Sperrylite ($PtAs_2$)

A rare platinum mineral, sperrylite may occur as minute tin-white, metallic cubes. Sperrylite was found at the New Rambler mine in the Medicine Bow Mountains.

Sphalerite (ZnS)

Also known as "zinc blende," sphalerite has a wide range of colors, but most sphalerite in Wyoming is reddish-brown to yellowish-brown. It occurs in resinous, translucent to opaque masses commonly associated with galena and will dissolve in HCl and give off H_2S (rotten egg) gas.

Stephanite (Ag_5SbS_4)

Stephanite is a soft (H=2 to 2.5), brittle, iron-black metallic mineral. Stephanite commonly occurs in short prismatic crystals with pseudohexagonal habit but also in massive form.

Stromeyerite (AgCuS)

Stromeyerite is a heavy (SG=6.15 to 6.3), soft (H=2.5 to 3) mineral occurring in compact steel-gray metallic masses, and rarely in orthorhombic twinned crystals.

Sylvanite [$(Ag,Au)Te_2$]

Sylvanite forms bladed to imperfectly granular crystals with metallic luster and is steel-gray to silver-white in color.

Tenorite (CuO)

Tenorite is also known as melaconite. Tenorite is a jet-black copper oxide usually found as stains on other copper minerals. It will partially replace a weathered rock hammer with native copper when the hammer is rubbed into the mineral wetted with dilute hydrochloric acid.

Tetrahedrite [$(Cu, Fe, Zn, Ag)_{12}(Sb, As)_4S_{13}$]

Tetrahedrite is a brittle, relatively soft (H=3.5 to 4), dark-gray to black, metallic mineral found in granular masses. Good crystals of tetrahedrite have a distinctive tetrahedral habit. A variety of tetrahedrite which is rich in silver is known as freibergite; a variety of tetrahedrite rich in arsenic is known as tennantite.

Wolframite [$(Fe,Mn)WO_4$]

Wolframite is a heavy (SG=7.12 to 7.51), brownish-black to black, submetallic mineral. Wolframite commonly occurs in bladed crystals.

Wulfenite ($PbMoO_4$)

Usually, wulfenite occurs in bright yellow to orange, thin tabular translucent to opaque crystals with prismatic cleavage.

The Absaroka Range in northwestern Wyoming includes several volcanic centers, some of which contain a variety of ore minerals associated with altered volcanic rocks and veins. Mineralization associated with these volcanic centers (**Figure 3**) includes porphyry copper-silver deposits that generally are low-grade polymetallic deposits. Because of the low-grade mineralization, good ore mineral specimens are not common except where these deposits include veins and fissures. On some vein and fissure deposits, high-grade mineralization may yield very attractive ore samples.

Eagle Creek area

Eagle Creek porphyry. This deposit in sections 16, 17, 20, and 21, T51N, R109W, is located near the western boundary of the Washakie Wilderness just east of Yellowstone Park, about 40 air miles west of Cody. The area is accessible by 12 miles of pack trail (Eagle Creek trail) into the wilderness. *Recommended map: U.S. Geological Survey topographic map of the Carter Mountain 1:100,000-scale Quadrangle.*

The country rock is composed of andesite flows and flow breccias of the Trout Peak Trachyandesite (Sunlight Group). Mineralization is related to the emplacement of an irregularly shaped intrusive of average latite composition. This latite porphyry was selectively fractured and mineralized, and exhibits stockwork mineralization near its east-central edge. The intrusive is located in a topographic saddle.

Minerals found include disseminated pyrite along with narrow pyrite-, galena-, sphalerite-, and chalcopyrite-quartz veinlets (<1 inch wide) in the altered-silicified latite; and pyrite and chalcopyrite in the gray latite porphyry (Galey, 1971). Some placer gold was reported along Eagle and Crouch creeks near the intrusive (Wilson, 1955a).

Kirwin district

The Kirwin mining district is located near the headwaters of the Wood River (Ts45 and 46N, R104W), 33 miles southwest of Meeteetse (**Figure 70**). Access to this area is limited to hiking trails. The area is highly mineralized with three large mineralized porphyries and numerous veins. Dave Miller (personal communication, 2000) estimated that Kirwin hosts $2.4 billion in identified metal resources.

A variety of copper, lead, zinc, and silver ore minerals have been found in the district including pyrite, chalcopyrite, sphalerite, galena, tetrahedrite, molybdenite, stephanite, malachite, azurite, cuprite, and native gold. Gangue minerals include specular hematite, siderite, barite, calcite, limonite, quartz (amethystine), and dolomite (Hewett, 1912).

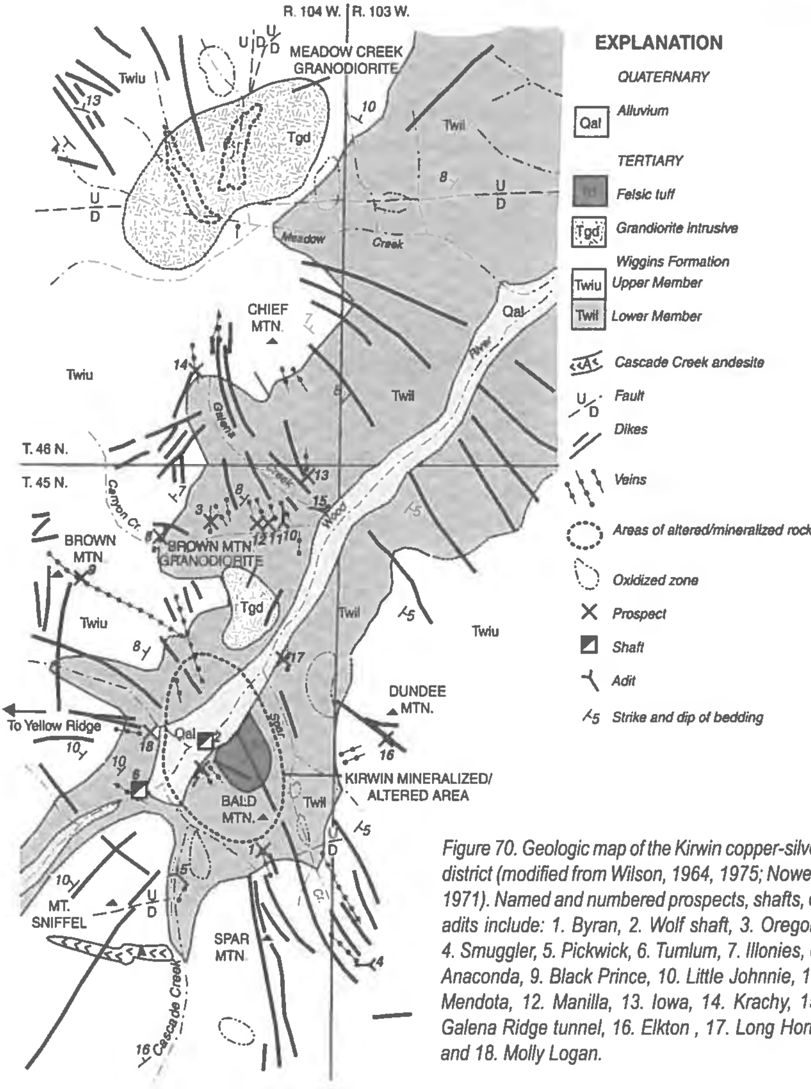


Figure 70. Geologic map of the Kirwin copper-silver district (modified from Wilson, 1964, 1975; Nowell, 1971). Named and numbered prospects, shafts, or adits include: 1. Byran, 2. Wolf shaft, 3. Oregon, 4. Smuggler, 5. Pickwick, 6. Tumlum, 7. Illonies, 8. Anaconda, 9. Black Prince, 10. Little Johnnie, 11. Mendota, 12. Manilla, 13. Iowa, 14. Krachy, 15. Galena Ridge tunnel, 16. Elkton , 17. Long Horn, and 18. Molly Logan.

Some veins in the district have yielded very high-grade silver values (see Silver), suggesting that excellent silver specimens have probably been found in the past. In fact, most silver-bearing minerals identified in Wyoming have been recognized in this district. Recommended map: U.S. Geological Survey topographic map of the Ramshorn 1:100,000-scale Quadrangle.

Bryan vein. The Bryan vein is located along the northern flank of Spar Mountain in section 13, TT45N, R104W, immediately south of Bald Mountain. Thirty-one samples taken over a strike length of 98 feet on the vein averaged 29.5 opt Ag, 0.13 opt Au, and 0.73% Cu (Rostad, 1982). The high values suggest that some silver-mineral specimens should be found here.

Galena Ridge tunnel. A select 0.5-foot-wide sample, collected across the Mendota vein in the Galena Ridge tunnel (N/2 section 1, T45N, R104W), averaged 101.35 opt Ag and 0.283 opt Au (Rostad, 1982). This extremely high assay value for silver suggests that argentiferous minerals must be present in this vein.

Little Johnnie mine. The Little Johnnie vein located in N/2 section 1, T45N, R104W, was prospected from an adit between Canyon and Galena creeks about a mile east of the Oregon prospect. Samples from the mine yielded very high silver values. According to Rostad (1982), 1.5-foot-wide samples yielded values as high as 64.7 opt Ag and 0.12 opt Au. The best values were obtained at the mine face, where work had stopped.

Oregon prospect. The Oregon prospect (NE section 2, T45N, R104W) was dug on the Oregon vein on the north side of Canyon Creek, a little more than a mile north of the Kirwin ghost town. Samples from the prospect yielded 17.8 opt Ag and 0.08 opt Au across 3-foot widths (Rostad, 1982).

New World district

The district is located in T58N, R109W, along the Montana-Wyoming border adjacent to Cooke City, Montana, (Hausel, 1997a). The Goose Lake and Henderson Mountain stocks north of Cooke City are the principal centers of mineralization.

Mineralization at Henderson Mountain extends outward from contact metamorphic gold-copper deposits, into copper-lead deposits, and then into copper-lead-zinc mineralization. Even farther from the Henderson Mountain stock, mineralization takes on the characteristics of complex lead-silver-zinc deposits which grade into silver-bearing sideritic calcite veins, and finally into barren carbonate veins. The better mineral deposits developed where the veins cut limestone beds and form replacement deposits in the Pilgrim Limestone (Gallatin Formation equivalent) of Late Cambrian age (Lovering, 1929; Reed, 1950; Butler, 1965). *Recommended map: U.S. Geological Survey topographic map of the Cody 1:100,000-scale Quadrangle.*

Irma-Republic vein. The Irma-Republic mines in N/2 section 20, T58N, R108W, are developed on a vein associated with the Henderson Mountain complex, adjacent to the Montana-Wyoming border. The vein is a fracture-filling and replacement vein in the Pilgrim Limestone.

Ore minerals found on the Irma-Republic property include galena, sphalerite, pyrargyrite, chalcopyrite, polybasite(?), anglesite, cerussite, proustite, native silver, freibergite, argentite, and rhodochrosite. Gangue minerals include quartz, jasperoid, calcite, dolomite, manganian ankerite, arsenopyrite, pyrite, marcasite, pyrolusite, psilomelane, and iron oxides (Butler, 1965). Some oxide ore recovered from the mine assayed as high as 1000 opt Ag (Lovering, 1929).

Sunlight district

The Sunlight district located 40 miles northwest of Cody is an extensive porphyry copper-silver district with associated mineralized veins. Ore minerals reported in the region by Parsons (1937) included chalcopyrite, pyrite, galena, tetrahedrite, sphalerite, native gold, sylvanite, bornite, famatinite, enargite, wolframite, proustite, stromeyerite, bournonite, malachite, azurite, covellite, anglesite, cerussite, cerargyrite, and chalcocite. The ore minerals often occur with gangue minerals in veins, including quartz, magnetite, limonite, siderite ($FeCO_3$), ankerite [$Ca(Fe,Mg)(CO_3)_2$], calcite ($CaCO_3$), adularia ($KAlSi_3O_8$), and barite ($BaSO_4$). *Recommended map: U.S. Geological Survey topographic map of the Cody 1:100,000-scale Quadrangle.*

Copper Lakes prospects. This property includes a group of prospects situated in the vicinity of Copper Lakes in sections 21, 22, and 28, T54N, R107W, about one mile east of Stinkingwater Peak. Samples from some prospects yield high silver values. Samples ranging from a trace to 24.32 opt Ag, with minor copper, lead, zinc, and gold have been reported (Nelson and others, 1980).

Malachite vein. Located on the divide between Fall and Sulphur creeks in sections 22 and 27, T54N, R107W, this vein is reported as 6 to 12 feet wide with an 18-inch-wide streak of high-grade chalcocite. The vein was traced for 2100 feet on the surface (Osterwald and others, 1966).

Painter mine. The Painter mine is located on the western flank of the upper Silvertip Basin at 9370 feet elevation in W/2 section 29, T54N, R107W. Eight samples collected from the mine dump contained assays that ranged from 0.12 to 3.53% Cu, 0.02 to 0.08% Pb, and 0.04 to 0.10% Zn, a trace to 0.07 opt Au, and 0.47 to 3.03 opt Ag (Nelson and others, 1980). Other samples from the mine included: dump material tested in 1935 that ran 3.85% Cu, 0.06 opt Au, and 4.62 opt Ag; a sample collected in 1966 that assayed 14.9% Cu, 10.6% Pb, and 5.6 opt Ag; and an average of eight random dump samples collected in 1969 that ran 5.16% Cu, 0.06 opt Au, and 6.1 opt Ag

(Rich, 1974). Based on the assays, this property should contain a variety of copper-, lead-, and silver-bearing minerals.

Winona prospects. These included a group of claims known as the Greenhorn, Uncle Frank, Malachite, Copper Queen, Copper King, Mohawk, Copperopolis, Granite Mountain, Butte, Doubtful, Gopher, Hidden Treasure, and B & S (Rich, 1974; Nelson and others, 1980). All were near Winona Camp at the head of Sulphur Creek Basin.

Parsons (1937) reported the ore mineralogy on these prospects was dominated by chalcopyrite and pyrite with microscopic amounts of tetrahedrite, galena, and sphalerite. Gold was reported in sylvanite and as rare native grains in veinlets in chalcopyrite. Beeler (1907a) reported that a 6-foot-wide vein on the Malachite claim contained a high-grade streak of chalcocite.

Black Hills

Some relatively good ore specimens have been found along Black Buttes in the Black Hills. Other ore specimens are found in the Bear Lodge Mountains north of Sundance. The Black Buttes lie 12 miles west of Mineral Hill and 8 miles south of Sundance. They are Tertiary alkalic igneous plugs with compositions similar to alkalic igneous rocks at Mineral Hill and in the Bear Lodge Mountains.

Locally, lead-silver-zinc mineralization occurs in a tabular zone along steeply dipping joints in the Mississippian Pahasapa Limestone. The mineralization is located a few feet above the contact with a Tertiary trachyte porphyry sill, and replaces limestone, fills cavities, and cements limestone breccia; the mineralization was accompanied by strong silicification (Elwood, 1979; Hagner, 1942b).

The most abundant ore mineral present is white hemimorphite which occurs in cavities and as replacements of algal structures in limestone. Other ore minerals include galena, sphalerite, fluorite, wulfenite, cerussite, and cuprite (Hausel, 1988c; Hagner, 1942b; Hayden, 1871). Some galena from the area assayed as high as 200 opt Ag (Knight, 1893). *Recommended map: U.S. Geological Survey topographic map of the Sundance 1:100,000-scale Quadrangle.*

Bear Lodge Mountains

Copper Prince mine. This mine is located in NW section 17, T52N, R63W, adjacent to the Warren Peaks road and about 1.25 miles north of the peaks. Dump material from the mine contains malachite and chrysocolla with small scattered particles of native gold (Jamison, 1912) and some cuprite (Chenoweth, 1955).

Southeastern Bear Lodge Mountains. A 150-foot-deep shaft was sunk adjacent to the Bear Lodge truck trail about 1.5 miles northeast of the intersection with the Warren Peaks road. The dump contains malachite, iron oxide, cuprite, and chrysocolla (Chenoweth, 1955), which are all found as fracture fillings in altered porphyritic syenite(?). The copper minerals are associated with light green and white opal in veinlets (see **OPAL**).

Black Buttes

Black Buttes prospect. The prospect is located in NE section 26, T50N, R62W **(Figure 42)**. Mineralization accompanies silicification in a contact breccia in the Mississippian Pahasapa Limestone, where it has been intruded by Tertiary trachyte. The breccia consists of limestone clasts cemented by massive galena. The galena is accompanied by hemimorphite, minor fluorite, jasperoid, and wulfenite. Elwood (1979) also reported sphalerite. The hemimorphite occurs as tiny radiating white prismatic orthorhombic crystals filling vugs in a reddish-brown jasperoid. The wulfenite is found in the same host rock, and occurs as very distinctive, resinous, transparent yellow to yellow-orange crystals with prismatic habit. Also present is minor sphalerite (dark, resinous brown), fluorite (deep purple), and galena (in gray masses that fill fractures). When a fresh surface is exposed, the galena exhibits shining, steel-gray metallic luster and cubic habit.

Granite Mountains

The Rattlesnake Hills in the northern Granite Mountains appear to be a major gold district (see Hausel, 1996e). Although ore minerals are uncommon in this area because much of the gold is disseminated and low-grade, some arsenopyrite occurs in a few prospects. *Recommended map: U.S. Geological Survey topographic map of the Rattlesnake Hills 1:100,000-scale Quadrangle.*

Lost Muffler prospect. This prospect contains some arsenopyrite and pyrite.

NE SW section 26, T32N, R88W. In this area, some good specimens of specular hematite have been found in a localized pod along the southern margin of the Rattlesnake Hills in a breccia zone along the North Granite Mountains fault.

SE NE section 33, T32N, R88W. At this location near the previous occurrences, small veins of specular hematite up to 0.5 inch wide occur within an ENE-trending felsic dike on the east side of the drainage (Wayne M. Sutherland, personal field notes, 1999).

Copper is found in vein deposits; associated with hematite in Precambrian schists; as replacement deposits along unconformities between the underlying Precambrian schists and overlying Paleozoic limestones; and associated with zinc in metasedimentary-hosted massive sulfide deposits and unconformity deposits. **Figure 3** shows locations of most of the mineralized areas in the uplift.

This eastern Wyoming uplift exposes eugeoclinal metasedimentary and metavolcanic rocks in its core. Excellent pillow basalts lie in a canyon wall east of the Michigan mine in Goshen County, and stromatolitic dolomites occur both east of the Guernsey Stone Company quarries and south of the Sunrise iron mine in Platte County (Snyder and others, 1989). Snyder (1980) indicated that the supracrustal rocks are Archean in age. Previous investigators reported the metamorphics to be Proterozoic in age (Millgate, 1965).

According to Ball (1907), lenses of copper in Precambrian metacarbonates were generally localized within the first 50 feet below the base of the overlying Guernsey Formation. The mineralization typically gave out within the first 20 feet below the base of the Guernsey. The copper ore occurs in veinlets along bedding planes accompanied by brecciation, and is closely associated with iron-stained rock or hematite, suggesting the iron acted as a precipitant.

Other copper lenses were found in Precambrian schist, quartzite, and jaspery rocks. The ore also was limited at depth, extending downward from the blanket deposits in the Guernsey Formation. Copper also occurs as lenses in iron ore (hematite) deposits and in heavily iron-stained jasper. This type of copper ore was developed (mined) at the Sunrise iron mine; initially, the deposit was mined for copper in the 1880s until the copper was mined out. In the early 1900s, the mine became the largest iron-ore producer west of the Mississippi River (Dyck and others, 1994).

The blanket deposits at the base of the Guernsey Formation occur as lenticular to tabular masses in a basal sandstone. These masses extend horizontally but do not extend vertically into the overlying limestone beds of the Guernsey. In many places, stringers of ore extend downward from the basal Guernsey sandstone, through the Guernsey-Precambrian unconformity, and into the Precambrian crystalline rocks. These deposits are generally less than 3 feet thick but locally reach 20 feet thick where copper extends down into Precambrian limestone and dolomite. At some localities, the copper was concentrated and enriched in pockets along a paleokarst surface developed in the Precambrian rocks (Ball, 1907). Copper-zinc-silver and minor gold occur in some metasedimentary massive sulfide deposits here.

Ore minerals in the Hartville area reported by Ball (1907) include malachite, azurite, chrysocolla, chalcocite, tennantite(?), native copper, bornite, covellite, cuprite, and chalcopyrite. Ball (1907) also reported gold values from iron-stained schist that were closely associated with copper at several localities in the uplift. *Recommended maps: U.S. Geological Survey topographic maps of the Lusk and Torrington 1:100,000-scale quadrangles.*

Lusk area

Near the extreme northern margin of the Hartville uplift, some ore minerals are reported near the western edge of the town of Lusk at the Silver Cliff mine.

Silver Cliff mine. This mine lies at the top of a hill in section 7, T32N, R63W. Much of this hill consists of Precambrian muscovite schist interbedded with thin lenses of limy schist unconformably overlain by calcareous Flathead(?) Sandstone or possibly Guernsey(?) Formation sandstone.

Silver-copper-gold mineralization was discovered on this hill in 1879. The Silver Cliff mine opened in 1880, and was worked on a small scale for copper and silver until 1884. Years later, uranium was discovered and some uranium ore was shipped between 1918 and 1922, and between 1951 and 1953 (Bromley, 1953). The mine was developed by a 285-foot-deep shaft with a 1200-foot inclined adit driven to the bottom of the shaft. Five levels were established with 1600 feet of drifts.

A variety of ore minerals were recovered from the mine including native copper, native silver, chalcocite, malachite, azurite, cuprite, chrysocolla, metatorbernite [$Cu(UO_2)_2(PO_4)_2 \cdot 8H_2O$], uranophane [$Ca(UO_2)_2Si_2O_7 \cdot 6H_2O$], *gummite* (generic name for gum-like uranium minerals), and pitchblende (UO_2) in calcite, limonite, and clinozoisite gangue. The mineralization lies within and adjacent to a high angle reverse fault, and in a blanket deposit of iron-stained sandstone at the base of the Paleozoic sedimentary section adjacent to the mineralized fault (Wilmarth and Johnson, 1978). Because of the presence of uranium minerals in the ore assemblage, any samples collected from the Silver Cliff mine will probably be radioactive.

McCann Pass

A number of prospects with some copper and pyrite associated with limonite gossans occur in the McCann Pass area.

Charter Oak mine. This mine is located on the south side of McCann Pass in SE section 26, T28N, R65W. A shaft was sunk in a cupriferous gossan in muscovite schist and quartzite that exposed malachite, chrysocolla, and chalcocite in fractures and in a 4-foot-wide vein crosscutting the vertically dipping schist (Ball, 1907). Two samples collected from the mine dump yielded 8.6% and 1.4% Cu, respectively (Hausel, 1997a). The chrysocolla is relatively common in some samples and occurs as green to turquoise-bluish-green botryoidal replacements and encrustations.

Gossan Hill. This area is in SW section 23, NE section 26, and E/2 section 27, T28N, R65W. Massive bronze-metallic, weakly magnetic pyrrhotite, with some bronze-metallic disseminated pyrite, and greenish malachite are found in graphitic schist in the Gossan Hill area, along with spongy to massive (rusty) iron oxides from oxidation of pyrite and pyrrhotite.

Rawhide Buttes

The Copper Belt group of mines occurs in the Rawhide Buttes area in the northern Hartville uplift. The mines were named Gold Hill, Omaha, and Lucky Henry along with the Emma open cut. Some good specimens of copper ore have been found on the mine dumps in past years.

Gold Hill and Omaha shafts. Two shafts located in S/2 section 2, T30N, R64W, were sunk on a 7- to 20-foot-wide band of schist between two metadolomite units. The Gold Hill workings exposed a 6-foot vein with 2 feet of iron-stained schist in the footwall. Veinlets of malachite, chrysocolla, and lesser chalcocite were found in the vein. Fractures in a shattered quartz vein parallel to the schistosity contained stringers and masses of chalcocite and bornite partially altered to malachite, chrysocolla, and azurite.

The Omaha shaft contains malachite, azurite, chalcocite, and chrysocolla, with barite gangue that occurs in stringers both parallel and crosscutting the foliation of the schist (Ball, 1907).

Lucky Henry incline. Located in N/2 section 11, T30N, R64W, the Lucky Henry was developed in a mineralized zone with dolomite in the hanging wall and iron-stained schist in the footwall. The ore was localized in the schist adjacent to the hanging-wall dolomite in two lens-shaped masses separated by barren schist. The mineralized lenses consisted of ramifying veinlets and stringers of malachite, and chrysocolla, with minor chalcopyrite (Ball, 1907).

Wildcat Hills area

In the Wildcat Hills, some copper was found in fissure veins and as replacements in the Precambrian rocks. Some copper was also reported in the Mississippian dolomites.

Copper Bottom. This prospect is located in SE section 23, T29N, R65W. Chrysocolla, malachite, and tennantite were described at the Copper Bottom prospect by Ball (1907).

Green Hope. This prospect is located in NW section 26, T29N, R65W. A coarse, conglomeratic hematitic-stained sandstone at the base of the Guernsey Formation (Late Devonian and Mississippian) overlies a rough, uneven paleokarst surface on Precambrian dolomite. Malachite, chrysocolla, azurite, chalcocite, and some olive-green olivenite were found as fracture fillings, as replacements for the cement in the sandstone, and locally replacing carbonate pebbles (Ball, 1907; Hausel, 1997a).

The mineralized sandstone and conglomerate average 3 feet thick, but in places the mineralization extends 20 feet below the normal contact into solution features on the Precambrian paleo-surface. Tufted crystal aggregates of malachite and botryoidal masses of chrysocolla are found in the solution cavities. White or yellowish calcite encrusts these minerals, and films of bluish-white chalcedony commonly cover the calcite. Thin stringers of malachite, chrysocolla, and azurite also extend downward into the Precambrian dolomite (Ball, 1907).

Laramie Mountains

Esterbrook district

Several old mines and prospects are found in the Esterbrook area in the Laramie Mountains south of Douglas. A variety of ore minerals are found in this district, including pyrrhotite, quartz, chalcopyrite, sphalerite, galena, pyrite, and calcite (**Figure 16**). *Recommended map: U.S. Geological Survey topographic map of the Laramie Peak 1:100,000-scale Quadrangle.*

Big Five prospect. This prospect is located 2500 feet north-northeast of the Three Cripples mine in SW SW section 10, T28N, R71W. The dump near a 50-foot-deep shaft contained rock with mostly pyrrhotite and bunches of chalcopyrite in quartz and feldspar gangue (Spencer, 1916). Traces of sphalerite were also detected (Greeley, 1962).

Esterbrook mine. The Esterbrook mine is located in SE section 9, T28N, R71W (**Figure 16**), on the Douglas claim. Galena was found in tabular open space fillings in hornblende schist. The mineralized body is 2 to 6 feet wide, trends N30°E, and dips vertically. In addition to the galena, pyrite, calcite, quartz, cerrusite, minor limonite, covellite, chalcopyrite, and traces of malachite were found (Beeler, 1904a; Greeley, 1962). Ore shipped from the property averaged 34.65% Pb, 1.3 opt Ag, and 0.035 opt Au (Beeler, 1902a).

Three shafts were sunk along the 500-foot-long mineralized trend. One shaft was sunk to a depth of 350 feet. On the main level at a depth of 335 feet, two drifts were developed. One was driven 300 feet to the south and the other was driven 100 feet to the north (Greeley, 1962). Today very little ore remains on the dump, (which has been converted to the village landfill), even though Spencer (1916) reported that six-foot-wide solid shoots of galena were intersected in the mine workings.

Eureka prospect. Beeler (1902b) located this prospect in sections 9 and 16, T28N, R71W, however his written directions to the prospect "...at the head of one of the tributaries of Little Horseshoe Creek, about one-half mile south and east of the Esterbrook mine..." places it near the line between sections 10 and 16 where an adit is shown on the Esterbrook 7-1/2 minute Quadrangle. An 8- to 20-foot-wide, north-trending quartz vein along a contact between schist with diabase is stained with limonite. Masses, disseminations, and streaks of pyrrhotite were discovered below the limonitic gossan at a depth of 12 feet. Chalcopyrite also occurs in the vein, and some gold was recovered from the gossan (Beeler, 1902b).

Kentucky Belle. The Kentucky Belle claims (section 1(?), T27N, R73W) are southwest of the Hoosier Boy claims beyond a divide between LaBonte and Horseshoe creeks. The Kentucky Belle shaft was sunk to a depth of 40 feet. The quartz vein is about 2 feet wide, and carries considerable chalcopyrite and some chalcocite (Spencer, 1916, p. 71).

Maggie Murphy mine. The Maggie Murphy mine is located about two miles south of Esterbrook (**Figure 16**) along the north side of Horseshoe Creek (E/2 E/2 section 21 and W/2 W/2 section 22, T28N, R71W). The property consisted of nine claims staked in 1903 that crossed the section line to the west into the easternmost part of section 21 (see Hausel, 1997a, figure 39, p. 82 for historical claim map). A 107-foot shaft was sunk adjacent to the section line in the center of the W/2 W/2 of section 22.

The Maggie Murphy shaft was sunk on a northeast-trending limonite-, minor malachite-, and azurite-stained gossan in amphibolite schist. The gossan crops out for several hundred feet along strike over a width of 10 to 20 feet. A few feet below the gossan, the shaft cut a 5-foot-wide pyrrhotite-rich vein. At about 50 feet deep, the vein was quartz-dominant and pyrrhotite-poor (Spencer, 1916, p. 60 to 61). Traces of sphalerite (Greeley, 1962) and some coffinite (Guilinger, 1956) were also found. The pyrrhotite is non-magnetitic to weakly magnetic. Specimens contain bronze-colored, metallic, hexagonal, granular pyrrhotite.

Maverick. A 50-foot-deep shaft was sunk on irregular, 3- to 10-foot-wide quartz veins that trend N45°W to N55°W and dip vertically in section 22 and 23, T29N, R71W [Greeley (1962, p. 44) places the location of this prospect in the SW section 34]. The quartz veins are closely associated with pegmatitic veins. The veins are vuggy, pyritic, stained with iron and hosted by granite (Spencer, 1916, p. 66). One 2- to 6-foot-wide quartz vein is stained by limonite and malachite. A few "kidneys" of chalcopyrite were found in this vein (Beeler, 1904b).

McGhee. This occurrence is in SW section 10, T28N, R71W. Minor chalcopyrite and traces of sphalerite occur in quartz-pyrrhotite mineralized zones. These strike northeasterly and dip vertically (Greeley, 1962).

Sauls Camp. This prospect is in NE SE section 22, T29N, R71W (**Figure 16**). The country rock at Sauls Camp is predominantly hornblende schist with a dominant foliation trend of N45°E. The schist is intruded by diabasic dikes conformable to foliation.

Shafts and drifts were dug on a copper-stained gossan in the schist and intersected lenses of chalcocite, chalcopyrite, pyrite, pyrrhotite, magnetite, and native copper. Some high grade ore with as much as 30% Cu, 6 to 8 opt Ag, and 0.03 opt Au was found on the property. About 100 tons of ore containing 9% Cu were mined.

Four hundred feet east of the main shaft, a highly magnetic zone was traced for 1000 feet along a southeasterly trend. The anomaly is strong enough to disturb a compass needle (Spencer, 1916, p. 66 to 67).

Snowbird group. This group of claims is located on the northwest slope of Elkhorn Mountain east of LaBonte Creek in NE section 21, T29N, R71W (**Figure 16**). Red granite hosts two narrow greenish schist layers interpreted as sheared diabase dikes. The schist strikes north-south and is 150 feet thick at the Snowbird group. Quartz veins, 6 to 8 feet wide in the schist, contain limonite, specular hematite, spots of copper carbonates and some gold. At the bottom of the 75-foot shaft, pyrite and chalcopyrite were found filling fractures, seams, and gouge zones in the quartz and schist (Beeler, 1907c; Spencer 1916, p. 68 to 69; Osterwald and others, 1966).

Tenderfoot group. The Tenderfoot group in S/2 section 3, T28N, R71W, consists of several claims staked at the turn of the century. According to Spencer, (1916, p. 65) the Tenderfoot group included a 2000-foot-wide belt of prospect pits and shafts developed in scattered limonite-stained gossans. Near the west side of the belt, a 150-foot-deep exploratory shaft was sunk and a southeast-trending crosscut was dug that terminated in barren rock without intersecting any mineralization. The principal ore mineral found is pyrrhotite (Greeley, 1962). Some chalcopyrite with gold and silver was found below the gossan (Beeler,1903a).

Three Cripples prospect. The Three Cripples prospect, located in NW section 15, T28N, R71W (**Figure 16**), was developed on a northeast-trending limonite-stained zone in schist southeast of Esterbrook village. A 96-foot-deep shaft was sunk on the limonite zone. Samples of pyrrhotite with some chalcopyrite can be found on the mine dump.

Trail Creek mine. This mine is located about 25 miles south of Douglas near the head of Trail Creek in NW SE section 10, T29N, R71W (**Figure 16**). Interlayered granites and schists strike northeasterly and dip gently to the northwest. The country rock is intruded by diabasic dikes that lie conformable to foliation of the granite and schist.

The granite is siliceous and often grades into quartz veins. The veins are fractured and contain limonite, hematite, and schist inclusions. Locally the veins show masses of azurite and malachite, and small amounts of copper- and iron-sulfides (Beeler, 1903b). Spencer (1916) reported malachite and chalcocite on the outcrops, but found little mineralization in the tunnel. Beeler (1904a) reported the property was developed by a 60-foot-deep shaft and a 360-foot-long crosscut tunnel.

In 1954, a small lens of uraninite in fresh unaltered hornblende schist wallrock was discovered 8 feet below the adit floor at the junction of two north- and northeast-trending, vertical shear zones. Both shear zones are radioactive where cut by the adit. The uraninite, coated by crythrite (cobalt arsenate), occurs as botryoidal and sooty coatings along shear zones and as disseminations in the hornblende schist (Guilinger, 1956). Guilinger (1956) reported that quartz, galena, pyrite, and arsenopyrite intergrown with disseminated chalcopyrite are found near the uranium mineralization, but in completely separate lenses and shear zone fillings. This suggests that the uranium mineralization represents a separate episode of mineralization.

Garrett area

Garrett prospect. The prospect is located in N/2 sec. 28, T25N, R73W.A few hundred yards east of the Garrett ranch house along the north bank of the North Laramie River, the prospect pit contains arsenopyrite-berthierite-bearing quartzite (**Figure 71**). Rusty quartzite samples, when broken, produce fresh surfaces of foliated gray quartzite with disseminated pyrite, arsenopyrite, and long prismatic metallic crystals of berthierite ($FeSb_2O_4$).

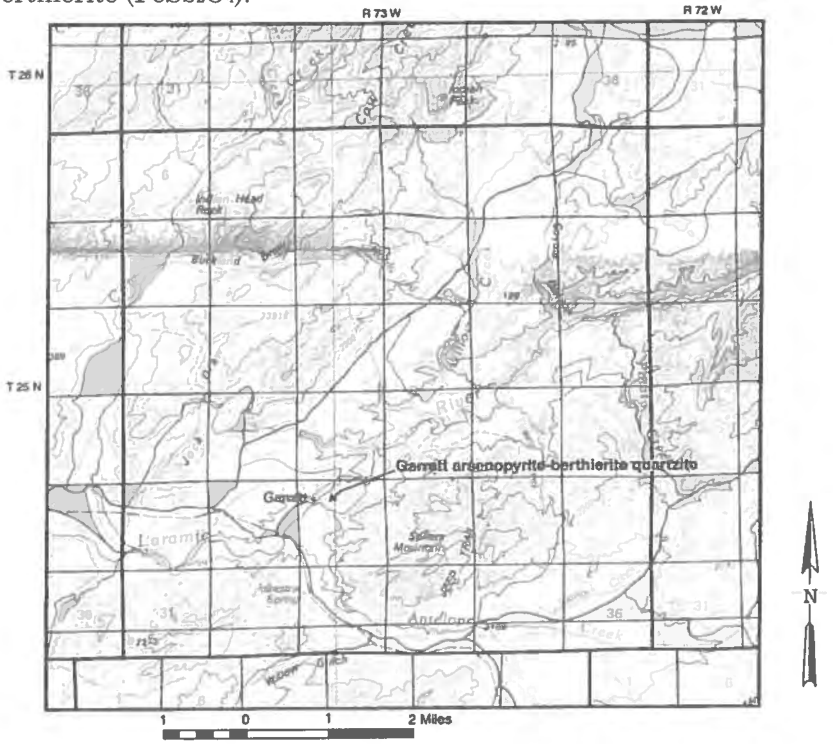


Figure 71. Location map of the Garrett area, adapted from U.S. Geological Survey 1:100,000-scale topographic map of the Laramie Peak Quadrangle.

The North Laramie River, the prospect pit contains arsenopyrite-berthierite-bearing quartzite (**Figure 71**). Rusty quartzite samples, when broken, produce fresh surfaces of foliated gray quartzite with disseminated pyrite, arsenopyrite, and long prismatic metallic crystals of berthierite ($FeSb_2O_4$).

Laramie anorthosite batholith

The Laramie anorthosite batholith forms a 350 mi2 complex in the central Laramie Mountains. Massive titaniferous-magnetite deposits have been mined at several localities in the batholith, of which one mine is discussed below. In addition to the titaniferous magnetite, speciments of anorthosite, labradorite (see **LABRADORITE**), kimberlite (see **KIMBERLITE**), copper and scheelite have been found in the complex.

Strong mine. This mine is located along Rogers Canyon road northeast of Laramie in NW NW section 4, T16N, R71W. From 1900 to 1915, the Strong

Mining Company mined some copper (Beeler, 1942). In 1942 the shaft was reopened to recover tungsten, which was used to manufacture hardened steel during World War II.

A shaft with five levels was sunk to 360 feet and included at least 1308 feet of tunnels by 1907 (Beeler, 1907b). Beeler (1942) later suggested that the total amount of development in the mine was considerably greater. The shaft was sunk in fractured diabasic and gabbroic dikes hosted by layered gneiss and schist in granite and anorthosite. Many of the fractures have been rehealed with quartz, and the anorthosite contains disseminated pyrite.

The vein at the Strong mine, described as 6 feet wide at the surface, swelled to 14 feet at a depth of 50 feet. On the 250-foot-level, a drift driven to the south cut 125 feet of crushed quartz containing chalcocite, bornite, and chalcopyrite. Another drift intersected 30 feet of streaks and masses of chalcopyrite in a cross vein. On the 350-foot-level, a drift cut to the north intersected streaks and spots of chalcocite, including a 15-foot-wide zone of chalcopyrite that had apparently replaced granite.

In the upper level of the mine, the chief minerals were copper carbonates with lesser amounts of chrysocolla, cuprite, and native copper. Below this level, the ores were chalcopyrite and bornite, with some chalcocite.

In 1942, the mine reopened to extract scheelite ($CaWO_4$), a glassy, milky-white tungsten-bearing mineral that strongly fluoresces light-blue under short-wave ultraviolet light (Osterwald and others, 1966). A second scheelite deposit was located on the nearby Yellow Pine property. Some molybdenite is also found as bright, silver-gray disseminations in the Strong quartz vein. There are also reports of some nickel mineralization at the Strong mine.

Medicine Bow Mountains

Historically, the Medicine Bow Mountains have hosted several mines and mining districts that contain ore minerals (**Figures 3** and **17**). Some of the mines are still evident today (**Figure 72**). *Recommended map: U.S. Geological Survey topographic map of the Saratoga 1:100,000-scale Quadrangle.*

Copper Ridge district

The Copper Ridge district lies near Mountain Home and the Pelton Creek area in the southern Medicine Bow Mountains (**Figure 3**). A few small prospects and mines in this region were developed for copper mineralization in granite. Specimens of copper carbonate can still be found on the dump of the American mine.

Figure 72. Historical mines in the Medicine Bow Mountains include the (a) Keystone mine on Douglas Creek as it appeared in 1905 (photograph from the S.H. Knight collection, American Heritage Center, University of Wyoming, used with permission), and (b) the Red Mask mine as it appears today.

American mine. This property is located one-half mile east of Mountain Home and south of State Highway 230 (**Figure 17**) in SW section 16, T12N, R78W. The property was developed on silicified, rehealed, N15°W-trending fractures in granite. Some mylonitic granite specimens collected from the mine dump are brightly colored by pervasive green malachite, blue azurite, and black tenorite (Hausel, 1997a).

French Creek district

Within the French Creek district are massive pyritiferous sheared graphitic schists. Beeler (1905a) reported that siliceous hematite schists found on Iron Creek contained small amounts of copper. One shaft sunk to a depth of 80 feet on the Ak-Sar-Ben group cut into the schist, exposing a ledge with considerable black iron and manganese oxides in graphitic schist. The nearby Raven group showed similar rocks.

Lorain Group. According to Beeler (1904c), pyrrhotite is found in graphitic schist in sections 11 and 12, T15N, R80W.

Raven Group. These claims are located in sections 15, 21, and 22, T15N, R80W, on Iron Creek. A siliceous gossaniferous (rusty) zone is stained by limonite and hematite. The gossan lies along the contact of altered graphitic schist with quartzite. The altered schist contains secondary silica.

The adjacent quartzite is iron-stained. The belt of siliceous material trends northeast for about 2 miles, is 30 to 70 feet wide, and contains specks of copper (Osterwald and others, 1966). A 200-foot-deep shaft cut a 5-foot-wide vein in the footwall quartzite and exposed pyrrhotite with minor chalcopyrite. Good specimens of massive pyrrhotite in graphitic schist can be found here. These can produce good ornamental stones when cut. Samples consist of dark-gray graphitic schist matrix with lenses and boudins of white quartz and bronze to rusty pyrite and pyrrhotite.

New Rambler district

The New Rambler district in the Medicine Bow Mountains includes a group of mines and prospects that were developed for copper hosted by shear zones. In addition to copper, platinum-palladium mineralization, gold, and silver along with a diverse assemblage of ore and gangue minerals were discovered at the New Rambler shaft (McCallum and Orback, 1968).

New Rambler mine. Supergene copper ore at the mine in section 33, T15N, R79W, consisted of covellite and chalcocite, along with very rare and well-defined crystals of a platinum-arsenide known as sperrylite. In addition, brightly colored arsenic sulfides were found in the mine workings including lemon-yellow orpiment (As_2S_3), orange-red realgar (AsS), and deep red crystals of lorandite (Rogers, 1912).

The oxidized zone at the New Rambler contained several ore minerals including malachite, azurite, chrysocolla, cuprite, tenorite, native copper, hematite, limonite, and chalcedony. The primary ore included pyrite, chalcopyrite, and quartz (McCallum and Orback, 1968). Many of these minerals could still be found on the mine dump when examined several years ago.

Sheep Mountain area

Barber mine. This mine is hidden in a forested area at the headwaters of two unnamed drainages along the southeastern flank of Sheep Mountain (W/2 SE section 15, T14N, R77W). The shaft was sunk to a depth of 150 feet in 1911 to mine copper and molybdenum (Hausel, 1997a). In 1991, the property included a caved mine shaft and the remains of three mine support buildings.

The mine was developed on a quartz vein in the Sherman Granite. Samples collected from the property included: (1) pink hypidiomorphic granular granite with traces of green malachite with accessory purple fluorite replacing biotite; (2) malachite-stained quartz breccia with fracture-filling, steel-gray ilsemannite ($MoO_8 \cdot xH_2O$); (3) fractured quartz filled with malachite-stained chalcopyrite, chalcocite, and bornite, with minor disseminated molybdenite; and (4) quartz with fractures filled by malachite-stained chalcopyrite, minor cuprite, and traces of copper sulfate. This is a good place to collect ore samples; however, the hike is invigorating. Access is from the southern portion of Sheep Mountain into the Medicine Bow National Forest. The climb to the top of Sheep Mountain is very steep.

Overthrust Belt

The Overthrust Belt in western Wyoming is formed of several thrust wedges of Phanerozoic sedimentary rocks that have been thrust eastward.

Scattered copper-zinc-lead-silver redbed deposits, metalliferous phosphorites, and black shales are found in the region. The principal mineralized district is the Lake Alice district near Cokeville, where good specimens of copper carbonate-bearing sandstone can be found.

The Lake Alice district is situated near the center of the Overthrust Belt at the northernmost tip of Fossil Basin (**Figure 3**). The mineralization is contained entirely within the uppermost part of the Nugget Sandstone (Triassic/Jurassic) and the lowermost sandstone and carbonate units of the overlying Gypsum Spring Member of the Twin Creek Limestone (Jurassic). Wherever significant mineralization is found, bleaching of the typically red host sediments is common. Prospect pits in the area are concentrated along the contact between the Nugget Sandstone and the Gypsum Spring Member.

The most common mineralization in the district is disseminated sulfides, which occur in various forms including interstitial pore fillings, poikioblasts, and clastic sand-grain replacements. The mineralization can also occur as sulfide veinlets and fracture fillings.

Ore minerals include chalcopyrite, chalcocite, digenite, bornite, sphalerite, idaite, loellingite, tennantite [$(Cu,Fe)_{12}As_4S_{13}$], covellite, pyrite, arsenopyrite, galena, malachite, azurite, cerussite, and an unidentified black cupriferous oxide. Gangue oxides include jarosite and neotocite ($Mn_2Fe_2Si_4O_{13} \cdot 6H_2O$) (Loose, 1990). Samples collected from the mine dumps generally are stained by malachite and azurite. Some sulfides can be found by breaking some of the copper-stained sandstones and examining the fresh surfaces.

Griggs mine. In the Griggs mine (section 7, T28N, R117W), bleached Nugget Sandstone, and gray silty sandstones and petroliferous cherty dolomites of the Gypsum Spring Member, contain copper, silver, zinc, and lead values. Ore minerals found on the dump include chalcocite, digenite, malachite, azurite, and cerussite. *Recommended map: U.S. Geological Survey topographic map of the Fontenelle Reservoir 1:100,000-scale Quadrangle.*

Owl Creek Mountains

The metamorphic rocks found within the Copper Mountain district, along the eastern edge of the Owl Creeks, contain a diversified assemblage of minerals.

The Copper Mountain district is located southeast of Thermopolis and northeast of Shoshoni (**Figure 18**). Metamorphic rocks in the district have been subdivided into three distinct areas by Gliozzi (1967), Hamil (1971), and Hausel, Graff, and Albert (1985). The southernmost unit consists of amphibolite, intercalated quartzofeldspathic gneiss, and mica schist. The central unit consists of banded iron formation, metapelite, quartzite, and amphibolite. The northern unit is dominated by amphibolite with subordinate quartzofeldspathic gneiss. Some scheelite, some feldspar, minor aquamarine beryl, minor amounts of gold and silver, and some copper have been reported in the district. *Recommended maps: U.S. Geological Survey topographic maps of the Lysite and Riverton 1:100,000-scale quadrangles.*

DePass mine. The DePass mine, located in section 23, T40N, R92W, was developed in a 30- to 50-foot-wide mafic (basaltic) dike. The dike has been fractured and rehealed by several milky quartz veins. Copper appears to be relatively evenly distributed throughout the dike. Ore minerals include chalcopyrite, malachite, azurite, cuprite, chalcocite, native copper, and chrysocolla. Gangue minerals include milky quartz, pyrite, earthy and specular hematite, limonite, goethite, and siderite (Hausel, Graff, and Albert, 1985). Some uraninite was also found in the mine and on the mine dump (Love, 1954). Some good copper samples can be found here.

McGraw mine. The McGraw mine, located in SW section 7, T40N, R92W, was developed by two shafts sunk into a belt of metasedimentary and metavolcanic rocks. The main shaft lies west of the secondary shaft, and is collared in weakly copper-stained, banded iron formation that exhibits secondary silicification. The secondary shaft intersected a cupriferous strike vein (Hausel, Graff, and Albert, 1985). This property is a good place to collect samples of copper-stained banded iron formation.

Romur property. A group of mining properties in section 22, T40N, R93W, known as the Stardust, Comet, and Whippet claims, contain disseminated grains of scheelite in lenses, pods, and quartz veins parallel to foliation in quartzofeldspathic gneiss.

Sections 20, 21, 22, 23, 27, 28, and 29, T40N, R93W. Scheelite also occurs in an east-northeast-trending belt 2.5 miles long by 0.25 miles wide. This occurrence consists of numerous small shoots and pods composed of scheelite crystals in quartz gangue.

Shirley Mountains

The Shirley Mountains are dominated by a core of granitic rock with occasional mafic dikes. *Recommended map: U.S. Geological Survey topographic map of the Shirley Basin 1:100,000-scale Quadrangle.*

Shirley Mountains prospect. A shallow prospect located in W/2 E/2 section 18, T26N, R81W, was dug on a north-south-trending mafic dike that has been pervasively invaded by quartz. The silicified zone also contains massive specular hematite that appears to be of jewelry quality. The prospect and dike lie immediately east of the Shirley Mountains road.

Sierra Madre

The Grand Encampment district includes the entire Sierra Madre and can be divided into a northern and a southern region (Hausel, 1986c). These regions are separated by a major east-trending suture known as the Cheyenne belt (locally known as the Mullen Creek-Nash Fork shear zone). North of the shear zone, the rocks are Early Proterozoic to Late Archean and form a miogeosynclinal wedge containing metaconglomerate, quartzite, phyllite, and metalimestone, with subordinate metavolcanics. Mineral deposits in this region include radioactive and locally auriferous quartz-pebble conglomerates, quartz veins, stratabound copper-bearing quartzite, and Recent gold placers (**Figure 7**). The district at one time was considered an important source of copper (**Figure 73**).

Figure 73. Boston-Wyoming copper smelter and mill at Riverside, Wyoming in 1905 (photograph from the Wyoming Division of Cultural Resources, Department of Commerce, used with permission).

South of the shear zone are Proterozoic metavolcanic and metasedimentary rocks. These include metabasalt, meta-andesite, metarhyolite, metatuff, and volcanogenic metasediments (Houston and others, 1975). Mineral deposits in this region include veins, shear zone deposits, and volcanogenic massive sulfides (Hausel, 1986c; Houston and others, 1983, 1992). Excellent samples of copper and zinc ore, garnets, and other minerals can be found in the Sierra Madre.

Broadway mine. This mine is located on East Fork Creek in SW section 32, T14N, R83W. Good skarn ore samples are found on this property. Ore minerals include massive sphalerite and minor galena with local disseminated chalcopyrite, chalcocite, and covellite. Small amounts of secondary malachite and chrysocolla are also found on the property. *Recommended map: U.S. Geological Survey topographic map of the Dudley Creek 1:24,000-scale Quadrangle.*

DeNault (1967) showed that the host rock at the Broadway mine was a pyroxenite with diopside and minor enstatite partially replaced by spessartine. One sample contained 35% olivine, and may represent a peridotite.

Samples collected from the property included dark reddish-brown and very heavy, banded massive sphalerite with some galena in a matrix of tremolite and spessartine. Some weathered surfaces of the massive sphalerite ore produce a brightly colored green-red-blue sheen in the sunlight. Other samples collected included a gray granodiorite with disseminated chalcopyrite and chalcocite. The host rock of the massive sulfide is a pyroxene-spessartine hornfels, and appears to be a skarn (Hausel, 1997a).

Charter Oak mine. This mine is located 6.5 miles northwest of Encampment on Puzzler Hill, on private property in section 24, T15N, R85W. Puzzler Hill consists of a mafic-ultramafic complex hosted by Late Archean gneiss north of the Cheyenne belt suture zone. Puzzler Hill appears as an ultramafic massif with sporadic mineralization. Based on hand specimens, the host rock is primarily pyroxenite with actinolite-chlorite schist. Mineralized samples from Puzzler Hill are also anomalous in copper, gold, silver, platinum, palladium, nickel, and cobalt. Spencer (1904) reported finding chalcopyrite, chalcocite, bornite, and azurite in a gangue of quartz, jasperoid, schistose wall rock, calcite, and some chalcedony at the mine.

Samples collected from the Charter Oak mine dump included some very attractive, massive specular and earthy hematite with copper carbonate and minor bornite and chalcopyrite in chlorite-actinolite-talc schist (Hausel, 1997a). When cut and polished, these rocks exhibit massive silver-colored metallic specular hematite with clots of green malachite and masses of bronze-colored chalcopyrite that are partially replaced by dark reddish-brown goethite. In addition, the specular hematite contains narrow zones of silicification, including some milky-white quartz and gray quartz. The gray quartz occurs as veinlets with pore spaces filled with tiny quartz prisms. Such specimens produce very attractive ornamental stones (**Figure 74, Plate 8**).

Creede property. This occurrence is located in N/2 section 10, T14N, R86W. Magnetite, pyrrhotite, and uncommon chalcopyrite are localized along a contact between hornblende schist and a norite intrusive (Spencer, 1904).

Doane-Rambler mine. The Doane-Rambler mine, located in NE section 25, T14N, R86W, was a relatively important copper mine in the early 1900s (Hausel, 1997a). The mine dump contains some chalcopyrite, bornite, chalcocite, covellite, malachite, azurite, cuprite, and chrysocolla in quartzite (Spencer, 1904). Platt (1947) and Roberts and others (1974) also reported red lorandite on the mine dump. Whalen (1954a) reported that anomalous radioactivity corresponded with greater amounts of copper.

High-grade copper ore consisted of brecciated quartzite cemented by chalcopyrite and chalcocite. Mineralization also occurred in siliceous mylonite, mica schist, and brecciated dolomite (Menzer, 1981). The ore was localized at intersections between fracture planes and bedding planes in the quartzite. The mine dump has been picked over for specimens, although a few good specimens of copper-bearing quartzite can still be found if one is persistent.

Ferris-Haggerty mine. The Ferris-Haggarty mine, located in section 16, T14N, R86W, was a significant source of copper during the first decade of the 1900s, and produced spectacular specimens of massive copper ore (**Figure 75a, Plate 9**). The mine was developed in a flexure fold along a massive quartzite-felsic schist contact where a 20-foot-thick ore shoot was localized in brecciated quartzite and metaconglomerate in the footwall (**Figure 75b, Plate 9**). Some of the high-grade ore was very rich and varied from 30 to 40% Cu with some silver and 0.1 to 0.4 opt Au (Lakes, 1904; Beeler, 1905a).

According to Short (1958), the principal ore minerals at Ferris-Haggerty included chalcocite and chalcopyrite with minor bornite and covellite. However, Platt (1947) indicated that covellite was an important constituent of the ore assemblage. Other minerals found on the dump include cuprite, pyrite, malachite, and chrysocolla. The dump was also reported to be slightly radioactive, although no uranium minerals were identified (Whalen, 1954b).

Through the years, the mine developed a reputation for spectacular ore specimens of massive copper, and because collectors have high-graded the mine dump for specimens for so long, it is now difficult to find good specimens on the dump. But in recent years, reclamation of the mine resulted in the reopening of the production tunnel along Haggarty Creek. The reopening exposed part of the ore zone several hundred feet into the tunnel (**Figure 75c, Plate 9**). This ore zone contains spectacular sheared copper mineralization along with cupriferous metaconglomerate. The metaconglomerate contains rounded clasts of granodiorite pebbles in a matrix replaced by massive copper. Copper minerals include malachite, bornite, and chalcopyrite.

Hinton-Verde mine. This mine is located in NE NW section 32, T13N, R85W. Samples collected from this property by Swift (1982) contained flecks of chalcopyrite, pyrite, and magnetite in a fine-grained hedenbergite matrix.

Weak to moderate copper-zinc sulfide mineralization was found in a ferruginous chert on the mine dump, cropping out as a reddish gossan traceable for 200 feet along strike, and in a felsic tuff breccia outcrop measuring 40 by 50 feet. Associated with these rocks is a chert and actinolite-epidote-garnet exhalite, several pods of metalimestone, and a tuff breccia containing rhyolite clasts up to 18 inches in length that is interpreted as a vent breccia (mill rock). On the property, a group of prospects dug in NW SW section 33, T13N, R85W, exposed an epidote-magnetite exhalite. The rock contains disseminated sphalerite, chalcopyrite, and bornite (Lawrence, 1981).

Itmay mine. The Itmay mine is located in section 14, T13N, R86W, within the Huston Park Wilderness Area, and is accessible only by trail. The mine was developed from a shaft and an adit. About 160 feet north of the shaft, magnetite iron formation with botryoidal pyrite coated by chalcopyrite occurs adjacent to volcaniclastics (mill rock). A sample of the magnetite iron formation assayed 5% Cu and a trace of gold (Hausel, 1997a). Some samples of massive botryoidal pyrite can be found on the dump, but they are now relatively uncommon. Prospects nearby contain traces of copper and zinc mineralization.

Kurtz-Chatterton mine. This mine is located in S/2 section 29, T14N, R84W. It is still one of the better localities in the region for copper minerals, as there are several prospects and the mineralized zone is relatively wide and 4000 feet long.

Vandenberge (1906) reported that the property contained five distinct veins ranging in width from 18 to 44 feet. The ore reportedly consisted of chalcocite and chalcopyrite (Spencer, 1904). Samples of brecciated Sierra Madre granite and milky quartz contain disseminated chalcopyrite; fracture-filling chalcocite with clots of brass-colored chalcopyrite; purple-, blue-, and brass-colored bornite; green malachite; reddish-gray chalcocite; and silver-gray specularite.

Meta mine. Situated at the head of a branch of South Spring Creek in SE section 13, T15N, R86W, the Meta mine was developed by a 100-foot-deep shaft on a 6-inch- to 6-foot-wide vein. The vein strikes roughly east-west and dips nearly vertical. Haff (1944b) described this property as being in section 24 or 25, but was uncertain of his location; adjacent unpatented claims at that time apparently extended into section 24.

Samples of vein material in the mine yielded a variety of minerals, including massive galena that is probably argentiferous, chalcopyrite, sphalerite, cerrusite, anglesite, pyrite, azurite, malachite, chrysocolla, hematite, limonite, hemimorphite, and smithsonite in a gangue of barite (Haff, 1944b).

North Fork group. This group of occurrences is located 14 miles south of Battle in section 13, T12N, R86W. Granite and "diorite" (from Beeler, 1905b) dikes trend northwesterly, dip to the northeast, and are cut by a N45°W-trending quartz vein known as the North Fork vein. Near the surface, limonite, malachite, and azurite were found. At depth the vein carried pyrite and chalcopyrite (Beeler, 1905b). Pease (1905) however, reported the ore consisted of galena and sphalerite with some wire silver. Some galena from the property assayed as much as 600 opt Ag and assays from some other oxidized ore reportedly yielded 33 to 73 opt Au.

A N88°E-trending vein crosscuts the North Fork vein. The crosscut vein is 23 feet wide and is mineralized throughout much of its width with pyrite, chalcopyrite, and some galena.

Portland mine. The Portland mine is located in E/2 SE section 30, T14N, R85W, south of Battle along the Huston-Standard Park jeep trail. The Portland mine was developed by 370 feet of tunnels with 120 feet of crosscuts, and a shallow shaft (Beeler, 1905a). The mine lies a short distance downslope and west of the Hercules mine.

Both the Portland and the Hercules mines lie along a sheared contact between granite to the south and metadolomite and phyllitic schist to the north. The primary target of the Portland mine, like the Hercules, was crosscutting veins in the metadolomite and schist (Spencer, 1904). The veins are narrow and can be traced for several hundred feet. In places, the metadolomite and schist are brecciated and impregnated with chalcopyrite. The principal mineralization is chalcopyrite and some chalcocite and bornite with hematite, quartz, calcite, and siderite gangue.

Section 8 mine. This mine is located in SE section 8 and NE section 17, T14N, R85W. This property is accessible by turning north off State Highway 70 onto Forest Service Road 443. On the ridge between Cow and Teddy creeks, a road marked *Dead End* continues on to the west. Continue west on this road for 4 to 5 miles from the dead end sign. This is a good place to collect a variety of minerals. *Recommended maps: U.S. Geological Survey topographic maps of the Red Mountain 1:24,000-scale Quadrangle and the Saratoga 1:100,000-scale Quadrangle.*

Section 8 mine was developed on an exhalitive massive sulfide. Samples consist of banded chert alternating with layers of massive sulfide consisting of pyrite, chalcopyrite, bornite, and cuprite. Some specimens show excellent open to tight folds.

The massive sulfide is hosted by mafic schist and garnet biotite schist of the Silver Lake Metavolcanics. Some amphibolites in the area also contain large *turkey track* bladed radiating amphiboles in a muscovite-sericite schist with 1/8-inch-diameter almandine garnets. Nearby, biotite schists contain large, 1/4- to 1/2-inch-diameter porphyroblasts of opaque and fractured reddish-brown, subhedral to euhedral almandine garnet (Hausel, 1997a; and personal field notes, 1997). Immediately west of the shaft and mine dump is an unprospected *gossan* (altered, rusty, iron-rich rock) which is probably similar to the gossan that the mine was initially developed on.

In the 1800s and early 1900s, prospectors searched these old mining districts for exposed quartz veins or for gossans. When a gossan was found, a pit or shaft was sunk on the gossan in the search of unaltered near-surface sulfide mineralization. Such gossans are typically the result of weathering of underlying sulfide minerals, and they often cap sulfide deposits.

In addition to collecting rock samples, the property may be a good place to check for mining artifacts with a metal detector, as it appears there once was a small mining community at this location. In addition to the relatively large mine dump, there is a large steam boiler, a large rotting pile of firewood, and the remains of at least four cabin sites adjacent to the mine dump. The remains of other cabins are overgrown and can be found in the nearby woods.

Three Forks group. The Three Forks group is located about 14 miles from Battle in sections 11, 12, 13, and 14, T12N, R86W. Smoky quartz veins in schist contain argentiferous galena and minor sphalerite and copper. The veins also contain abundant hematite near the surface, and both the quartz and hematite are reported to be auriferous (Pease, 1905). Some cerargyrite is also present (Osterwald and others, 1966).

According to Pease (1905), the Three Forks vein is well-defined and mineralized over a strike length of 6500 feet and extends from the south bank of the North Fork Little Snake River continuing south into Colorado. The vein trends N25°W, dips 82°NE, and is hosted by diorite. At one point, the vein (or complex of veins) is about 120 feet wide. Downslope from the Three Forks group (in sections 13 and 14) are the Pease placers. The gravels of the placers contain some gold and silver (Beeler, 1905c).

Wind River Range

South Pass greenstone belt

The South Pass greenstone belt in the Wind River Range was Wyoming's principal historical gold-mining region. Several veins, shear zones, and streams contain gold (see **GOLD**). A giant resource of banded iron formation occurs in the district, a portion of which was mined from the open pit near Atlantic City. Some scheelite (tungsten ore) was found in the Lewiston area, and arsenopyrite occurs in some mineralized veins along with occasional pyrite.

Other minerals in the region include copper, tourmaline, beryl, and aquamarine. The South Pass area is a very good place to search for mineral and rock specimens, and has a rich mining history. *We highly recommend* *that the mineral collector obtain copies of maps and reports by Hausel (1984, 1991a), as these will assist in finding and choosing collecting sites.*

Anderson Ridge fault. This occurrence is in section 21, T29N, R101W. Localized copper with associated manganese stains occur in a swell along the Anderson Ridge fault to the west of South Pass City. The host rock is brecciated within a zone that is several hundred feet wide. *Recommended map: Geologic map of the Anderson Ridge 1:24,000-scale Quadrangle (Hausel, 1986a).*

B & H mine. The B & H mine is located in section 22, T29N, R100W, between South Pass City and Atlantic City (**Figure 53**). The mine was developed on a N80°E-trending, near-vertical shear in metagreywacke of the Miners Delight Formation. Samples from the B & H lode consist of sheared quartz and metagreywacke containing some pyrite, arsenopyrite, tourmaline, and gold (Hausel, 1984, 1991a). The steel-gray arsenopyrite is closely associated with light-yellow-green *scorodite.* The scorodite is an arsenic-rich limonite that is an alteration product of arsenopyrite (arsenic-sulfide).

Burr mine. The Burr mine in the heart of the Lewiston district produced some scheelite along with gold ore (Hausel, 1991). The mine, located in section 8, T28N, R98W, produced stringers, veinlets, lenses, pods, and specks of scheelite that were found in sheared metagreywacke. According to Wilson (1951b) samples from the mineralized zone averaged 5% WO_3, and typically ranged from 2.5 to 70% WO_3.

Lewiston district. Several prospects and mines in the Lewiston district have yielded some scheelite along with gold. This includes prospects in SE section 23, T29N, R98W. Samples of milky-white veins in black metagreywacke contain disseminated scheelite. The scheelite is white in natural light and blends in with the white quartz, but with short-wave ultraviolet light, the scheelite yields a bright blue luminescence.

Lone Pine mine. The Lone Pine mine is located in SE section 9, T28N, R98W, along the north bank of the Sweetwater River within the Lewiston district. Several narrow shears, faults, and breccia zones were intersected by the mine workings. One narrow (1-inch-wide) arsenopyrite quartz vein was intersected by the mine. A few hundred feet east of the Lone Pine mine are two parallel quartz veins with considerable arsenopyrite (Hausel, 1991a). The arsenopyrite is a silver-colored, metallic mineral associated with yellowish-green stains of scorodite (oxidized arsenopyrite).

Snowbird mine. The Snowbird mine is located in section 6, T29N, R99W, and was developed in a shear zone and a carbonate-quartz-sulfide breccia vein hosted by metagreywacke in the Miners Delight Formation (**Figure 53** and **Figure 76, Plate 9**). Samples recovered from the breccia vein yielded weakly anomalous copper, silver, and gold (Hausel, 1989).

Attractive specimens of the carbonate-sulfide vein with lenses of pyrite with calcite and quartz can be found here. However, good mine dump samples of this material are uncommon. The better specimens have been dug from the iron-stained vein exposed in the hillside adjacent to the mine adit.

Wyoming Copper Mining Company. This occurrence is located in section 18, T29N, R100W. A shaft was sunk in ubiquitous breccia in Miners Delight Formation metagreywacke. The breccia is locally mineralized with milky quartz impregnated with chalcopyrite (Hausel, 1991b).

Southern Wind River Range

The southern Wind River Range west of the South Pass greenstone belt is dominated by Archean granites and gneisses intruded by diabasic dikes. Localized mineralization in this region includes molybdenite associated with quartz monzonite, and some minor copper associated with diabasic dikes.

Schiestler Peak prospect. Ore minerals occur in sections 30 and 31, T32N, R103W, and sections 24 and 25, T32N, R104W. Disseminated molybdenite is found in quartz diorite, granite, felsic dikes, quartz pegmatites, and quartz veinlets near shear zones in the Schiestler Peak area (Wilson, 1955b; Lee and others, 1982). Prospect pits on the southwestern flank of Schiestler Peak contain marcasite, pyrite, and chalcopyrite in addition to molybdenite (Benedict, 1982).

Schiestler Peak was extensively glaciated during the Pleistocene. As a result, specimens of nearly pure molybdenite in granite have been found downslope in glacial debris (Wilson, 1955b).

PERIDOT (OLIVINE)

Peridot, a gem variety of olivine, is a ferro-magnesium silicate with the general formula of $(Fe, Mg)_2SiO_4$. Olivine is an orthorhombic mineral that typically occurs as olive-green, deep green, yellow-green, brownish, or reddish tabular to nearly equal-dimensional mineral grains associated with mafic to ultramafic volcanic rocks. The hardness of peridot ranges from 6 to 7, and thus will produce faceted gemstones with a long-lasting polish.

With a specific gravity ranging from 3.2 to 4.3 for olivine, and an average specific gravity of 3.34 for peridot, the mineral will separate with the black sand concentrates during gravity separation. Cleavage is usually poorly developed in most peridot grains, but may occur on the *m*{010} or *m*{100} crystallographic planes.

Worldwide, sources for peridot are uncommon. Peridot has been found on the Red Sea Island of Zebirget and in Burma. Some peridot has also been collected from Kilbourne Hole and Portillo Marr in New Mexico, on the San Carlos Indian Reservation in Arizona, and from the Hawaiian Islands.

Sources of olivine are rare in Wyoming, and peridot has been unheard of in the Cowboy State until identified by Hausel (1998a). The presence of olivine has been described in some ultramafic to ultrabasic igneous rocks in the state. Serpentinized olivine was reported in metakomatiite in the South Pass and Seminoe Mountains greenstone belts, and in kimberlite in the State Line and Iron Mountain districts. Some relatively well-preserved but very rare olivine has been recognized in the Iron Mountain district (W. Dan Hausel, personal field notes, 1998), and olivine was also reported in some lamproites in the Leucite Hills of western Wyoming (Carmichael, 1967).

Bighorn Basin

Attractive, transparent, peridot grains are found in anthills along the Shoshone River within the town of Cody. Others have been found near Powell (Max Ruby, personal communication, 1999).

Central Laramie Mountains

John Ballard peridotite. Abundant fresh yellowish olivine with reaction rims was reported in an unaltered medium-grained peridotite in sections 21 and 22, T25N, R71W (Snyder and others, 1995).

Preacher Creek peridotite. A relatively large peridotite mass described by Albanese (1949) in sections 17, 19, 20, 29, and 30, T27N, R70W, is unaltered except where sheared, or where in contact with the enclosed quartz monzonite gneiss. Olivine crystals within the rock are generally transparent and range from 2 to 5 mm across.

Iron Mountain district

The Iron Mountain district in the Laramie Mountains (**Figure 24**) includes four major kimberlite dike-blow complexes–the largest has a strike length of 2.5 miles, and contains scattered blows ranging from tens of feet to 1000 feet across (W. Dan Hausel, personal field notes, 1998). Most kimberlites are either dikes or blows (root zones of pipes), with uncommon sills. The kimberlites have been mapped using outcrops, grassy vegetation anomalies, blue ground, and surface geophysical methods.

Some kimberlites are highly serpentinized. One group of kimberlites in the eastern part of the district contains abundant partially serpentinized olivine megacrysts. These are partially to entirely replaced by serpentine, magnetite, and hematite. A few preserved olivine grains occur in the kimberlites, but these are also partially serpentinized. No gem variety of olivine has yet been identified in these kimberlites.

Leucite Hills

The Leucite Hills consist of some very rare volcanic rocks known as lamproites (see **RARE AND UNUSUAL ROCKS**) located northeast of Rock Springs and north of Superior in southwestern Wyoming (**Figure 77**). The volcanic field is accessible by graded dirt roads and jeep trails leading from the two towns, and lie on federal, state, and private land. *Recommended maps: U.S. Geological Survey topographic maps and U.S. Bureau of Land Management surface management maps of the Rock Springs and Red Desert Basin 1:100,000-scale quadrangles.*

Olivine-bearing flows and/or plugs occur at South Table Mountain (sections 5, 6, and 7, T22N, R102W, and sections 1 and 12, T22N, R103W), North Table Mountain (sections 35 and 36, T23N, R103W, section 31, T23N, R102W, sections 1 and 2, T22N, R103W, and section 6, T22N, R102W), Wortman dike (sections 7, 17, and 18, T22N, R102W), Endlich Hill (sections 7 and 8, T22N, R102W), Hatcher Mesa (section 33, T22N, R102W), and Black Rock (described below).

At least three populations of olivine have been recognized in the Leucite Hills (Cross, 1897; Carmichael, 1967). The olivine includes anhedral xenocrysts, subhedral to euhedral microphenocrysts, and anhedral olivine mantled by phlogopite laths in disequilibrium with the host magma. These latter grains are thought to represent upper-mantle-derived xenocrysts. Olivine grains from Hatcher Mesa have characteristics comparable to olivines from mantle-derived lherzolite and harzburgite xenoliths found in kimberlite (Barton and van Bergen, 1981).

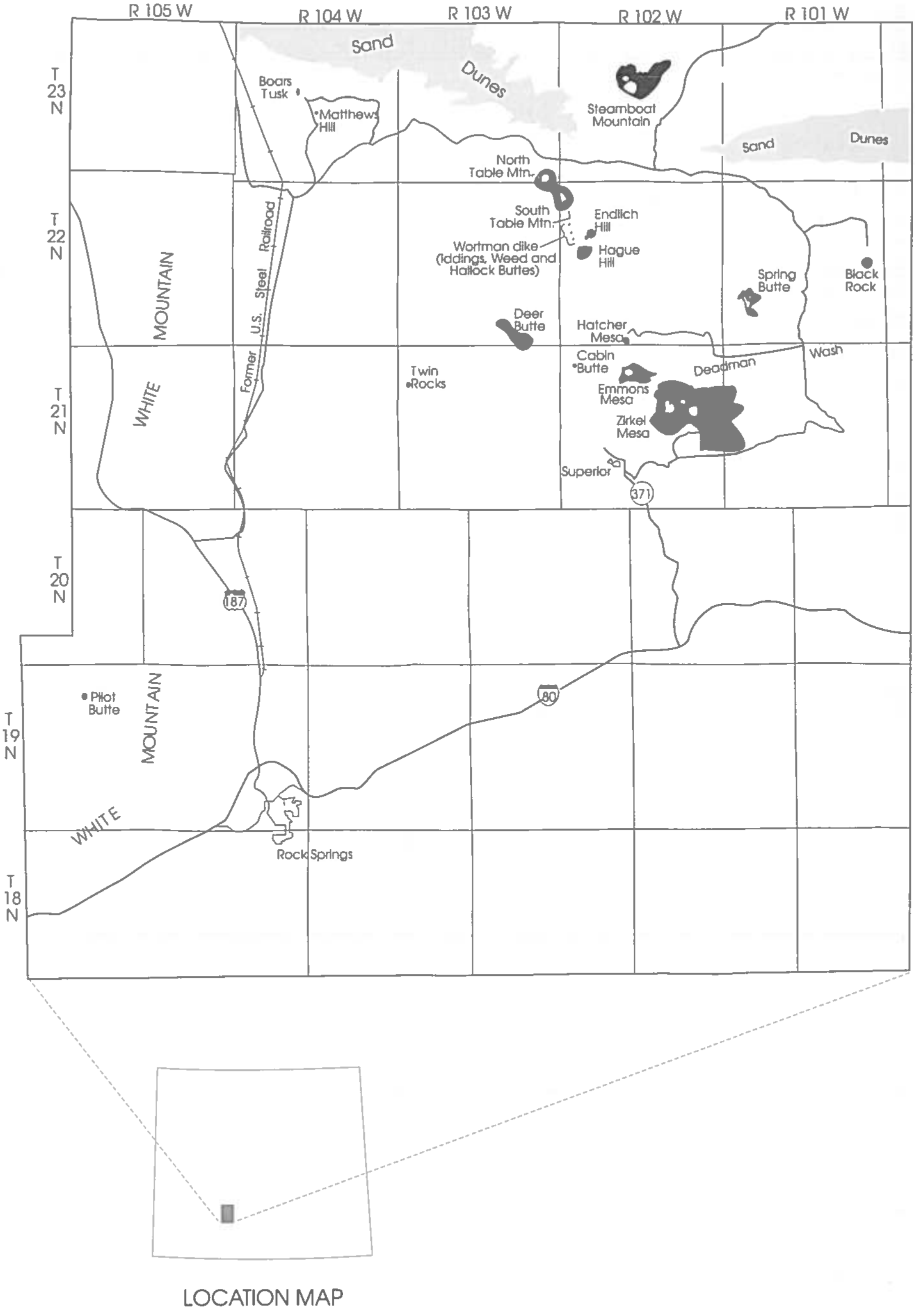


Figure 77. Map showing locations of volcanic rocks in the Leucite Hills (modified from Hausel, Love, and Sutherland, 1995).

Black Rock. Peridot grains up to one inch in diameter (**Figure 78, Plate 9**) are found in the host lamproite at Black Rock (sections 13 and 24, T22N, R101W). Hundreds of excellent, transparent, peridot grains up to 8 mm in length have been found in anthills along the flank of the lamproite (**Figure 79, Plate 9**).

The Black Rock peridot is olive-green, light green, and less commonly brown to reddish-brown. Much of the mineral is transparent with lesser translucent and uncommon opaque grains. Many peridot grains are quite clear, while others have frosted surface coatings with uncommon striations on the $m\{100\}$ face. Other grains have poorly developed cleavage in either one or two directions, and some grains exhibit mineral inclusions that tend to cloud the gemstone. But most appear to be gem quality.

Two anthills collected from the Black Rock area yielded more than 13,000 carats of peridot and industrial olivine in grains ranging from 2 to 8 mm in length (Hausel, 1998). The 8 mm grains are the apparent maximum size that could be sampled by the ants and carried to the anthill. Larger grains occur in the soils adjacent to the rock outcrops and also in the rock itself.

PYRITE (FOOL'S GOLD) (see ORE MINERALS)

QUARTZ (CHALCEDONY)

Quartz can be subdivided into: (1) crystalline quartz, and (2) cryptocrystalline quartz. *Crystalline quartz* includes clear transparent to translucent *rock quartz, milky quartz, rose quartz, smoky quartz, citrine (reddish-brown) quartz, blue quartz*, and *violet to purple amethyst*. These are found either as massive specimens or as well-formed prismatic hexagonal crystals typically terminated by a pyramid, or less commonly by bipyramids.

Cryptocrystalline quartz consists of microcrystalline to granular quartz known as *chalcedony*. Varieties of chalcedony include *chrysoprase* (apple-green chalcedony), *chrysocolla* (pale blue-green copper-bearing chalcedony), *agate* (banded gray, often occurring as cavity fillings), *onyx* (banded with alternating layers of light and dark chalcedony), *moss agate* (translucent chalcedony enclosing moss-like manganese or iron oxide dendrites), *jasper* (dark red or reddish-brown opaque chalcedony), *sard* (yellow, yellowish-brown, or reddish-brown translucent chalcedony), *carnelian* (translucent red to orange-red chalcedony), *bloodstone* (green chalcedony with red spots), *flint* (dark gray to black opaque chalcedony), *silicified wood* (wood replaced by chalcedony), *chert* (dull, opaque white or gray chalcedony), *botryoidal agate* and *jasper* (exhibiting an external form similar to a bunch of grapes), *dendritic agate* (moss agate with a distinct dendritic pattern), *flame agate* (red to orange plume jasper), *iris agate* (agate with spectral display of colors due to microscopic diffraction grating caused by alternating bands of higher and lower refractive indices), and *zebra flint* (shades of banded brown to gray flint or agate).

Many varieties of quartz and chalcedony have been found in Wyoming (**Figure 80**). Good specimens of prismatic quartz are uncommon in Wyoming, but the state has yielded many attractive specimens of chalcedony. Much of the crystalline quartz found in the state has been cloudy and translucent to opaque. However, specimens of chalcedony are quite varied, and Wyoming has become a favorite collecting ground for agate, jasper, flint, and petrified wood.

The Absaroka Range in northwestern Wyoming has produced a variety of petrified woods and agates. Along the western margin of the range, Yellowstone Park contains fossil forests at Specimen Ridge and Amethyst Mountain. Amethyst, as one might expect, is also reported at Amethyst Mountain. Wood casts, fossil cone casts, agatized seeds, and oval nodules have also been found in the Absarokas. These are clear, gray, brown, yellow, green, and red with patterns that include fortifications, banding, spots, moss, tea leaf, and iris agate. Wiggins Fork agates, petrified wood, and Montana agates are also found to the north along the Yellowstone River.

East of the Absaroka Range, chert, agate, and jasper occur in Paleozoic limestones along the eastern and southern flanks of the Bighorn Basin, and the north side of the Owl Creek Mountains. Woodcast agates are reported along the Bighorn River and on the western margin of the basin. Green agates and crystal-lined geodes have also been reported near Hamilton Dome. The Dryhead agate, a colorful red and white banded fortification agate, occurs in the northern Bighorn Basin. Rainbow agates are found along the Wind River near Riverton in the Wind River Basin.

In the Black Hills of northeastern Wyoming, chalcedony and amethyst are found, as are agates and jasperoids in stream gravels (along with particles and nuggets of gold) east of Sundance.

Although the Granite Mountains in central Wyoming are known for jade, several types of agate, jasper, petrified wood, and some rubies and sapphires have also been found. One of the better known varieties of agate is the Sweetwater moss agate, which is found in the Split Rock Formation. These agates fluoresce brilliant yellow due to the presence of hydrous uranium arsenate. They often contain a brown, opaque surface that can be removed by tumbling, which results in a highly polished, light gray to blue agate with black manganese dendrites. The Ice Point Conglomerate has rounded fragments of black petrified wood, and the Bridger Formation

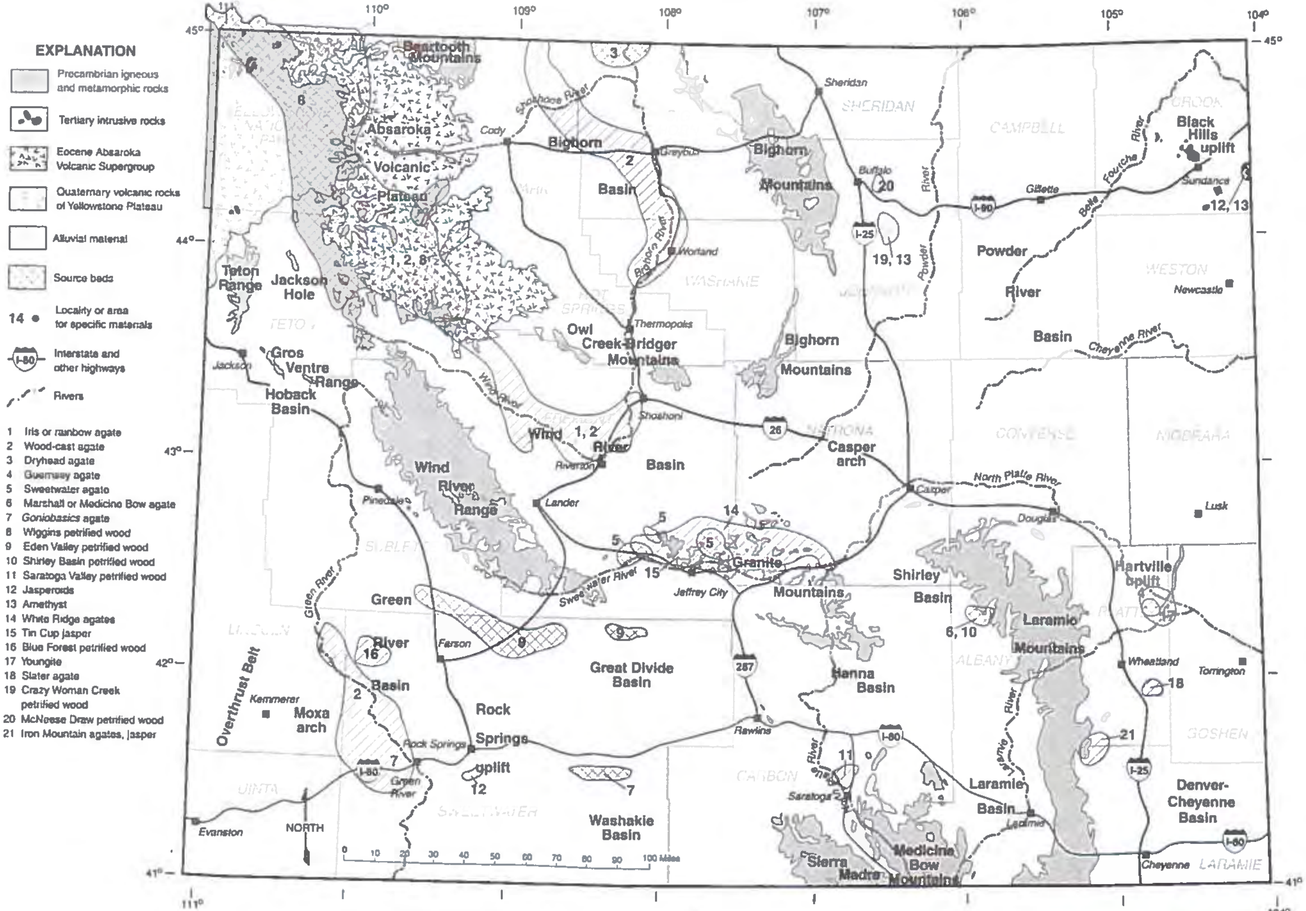


Figure 80. Quartz, chalcedony, and petrified wood localities in Wyoming (modified from Hausel, 1986b).

contains fossil tree stumps, fragments of petrified wood, and dark gray and brown agates (Love, 1970).

Moonstones, clear chalcedony balls coated with opal and white ash, and "Angel" agate are also found in the Granite Mountains. The agate occurs in nodules, is an attractive pale-greenish-gray color with a chalky-white surface coating, and fluoresces a brilliant greenish-yellow under ultraviolet light (Love, 1970).

In the Tin Cup district of the western Granite Mountains, beautiful jasperized breccias with angular fragments of blood-red, chocolate-brown, and butterscotch yellow-brown jasper occur along three prominent faults which were prospected for gold in past years. Some attractive chalcedony in this area is gray, banded, folded agate.

In the Green River Basin of southwestern Wyoming, petrified wood is found over a wide area around Farson in the Eden Valley. The Eden Valley wood resembles ordinary weathered wood on the surface but has an opaque, cream colored coating of silica covering a silicified black to brown core. Blue Forest agate is also found in the Eden Valley but west of Farson. This wood has a black to brown central core surrounded by clear blue chalcedony, producing some of the more striking and very attractive silicified wood found in Wyoming.

Bridger-type petrified wood occurs locally in the Bridger Formation near Oregon Buttes. Where partially silicified, it consists of black wood, but where completely replaced by silica, it ranges in color from brown to tan to green. Some clear chalcedony and vein moss agates are found nearby, as well as paleoplacer gold.

Reefs and beds of silicified gastropods (fossil snails), which were deposited in Eocene Lake Gosiute, are found throughout the Green River Basin and surrounding area. Some of the better collecting localities occur along Delany Rim south of Interstate 80 near Red Desert (west of Rawlins) and to the west of Rock Springs.

Banded jasperoids on Quaking Asp Mountain south of Rock Springs consist of dark- to light-gray banded agate with cross-cutting veins of quartz, and banded red, yellow-orange, and gray jasperoid and onyx. These occur in a very large and extensive silicified zone associated with ancient hot springs. Some of these will produce beautiful lapidary stones (Hausel and Sutherland, 1998).

Many agates near Guernsey in the Hartville uplift of eastern Wyoming have attracted rock hounds and mineral collectors for years, and many varieties of agate have received local names. For example, one local agate known as youngite forms distinct rehealed limestone breccias consisting of pink- to cream-colored breccia clasts of Guernsey Limestone that are rehealed and cemented by light-gray to grayish blue, banded, *drusy* quartz (encrustations or coatings of small crystals on interior surfaces or cavities), and chalcedony.

The drusy quartz fills fractures in the breccia and completely encases the brecciated limestone clasts. When polished, the contrasting colors of the quartz and breccia clasts provide very attractive lapidary stones. Under long wavelength fluorescent light, these samples yield a blue network of fluorescence that follows the bands of drusy quartz.

Another popular agate also found in the Guernsey area is the Slater agate. Slater agates form concretionary masses with white coatings. When cut, the interior of the stones is typically dark gray to black agate surrounding milky agatized interiors with small, fine, agatized dendrites. The surface of some of these agates is porous and may give an impression of a fossilized sponge.

In the Powder River Basin, west and south of the Black Hills, several varieties of petrified wood, chert, and jasper are found. The chert and jasper are associated with Paleozoic limestones along the western margin of the basin, and the petrified wood is derived from the Wasatch Formation. Poorly silicified, brittle petrified wood is found at the Dry Creek Petrified Tree site east of Buffalo. Another petrified wood, the Crazy Woman Creek wood, is more durable and more suited for lapidary. This wood is silicified, banded in shades of brown and white, and found in terrace gravels along Crazy Woman Creek east of the Bighorn Mountain front. East of Buffalo, amethyst-lined cavities were reported in some specimens of petrified wood.

Petrified wood, quartz, and chalcedony are found in the Laramie, Sierra Madre, and Seminoe mountains, and in the Shirley and Laramie basins, Goshen Hole, and Saratoga Valley in southeastern Wyoming. The most common forms of chalcedony in this region are agates and jaspers eroded from Paleozoic limestones, especially the Casper Formation (Permian-Pennsylvanian). Some petrified woods from this region are derived from silica (leached from Tertiary volcanic ash falls) that later replaced the wood.

In the Saratoga Valley, agatized and opalized woods and dendritic agates are found on the flats north of town. The host rock was possibly tuffaceous sandstone, siltstone, and claystone of the North Park Formation.

Beautiful specimens of jasperized iron formation are found in the Seminoe Mountains and in stream gravels near the Miracle Mile along the North Platte River. These rocks are magnetic and have alternating bands of black magnetite, dark gray quartz, and tawny to brown layers of jasper and grunerite. The source of this material is banded iron formation from Bradley Peak in the Seminoe Mountains gold district. This area should also be of interest to the gold prospector.

At Shirley Basin east of the Seminoe Mountains, several agates and jaspers have originated from Casper Formation limestones and sandstones. One agate is a reddish-brown jasper mixed with dark gray to black opaque agatized breccia. This rock consists of pink breccia clasts of Casper Formation sandstone cemented with reddish-brown and massive black chert coated with tiny grains of psilomelane (metallic, manganese oxide) that produces an attractive decorative stone. Along the southern end of the basin, Como Bluff is famous for silicified dinosaur bones in the Jurassic Morrison Formation.

Near Battle Lake in the central part of the Sierra Madre, quartz crystals occur in cavities and fractures in red granite. The quartz includes amethyst, rose, smoky, milky-white, and clear quartz crystals. Most are small and less than 2 inches in length. This region is also known for its old copper mines and several significant gold, platinum, palladium, nickel, and zinc anomalies.

Absaroka Range and vicinity

The Absaroka Volcanic Supergroup (Eocene), which includes the Wiggins Formation (a light-gray volcanic conglomerate and white tuff with clasts of igneous rocks) and the Wapiti Formation (formed of andesitic volcanic rocks), contains scattered fragments of petrified wood and agate. This volcanic supergroup forms much of the Absaroka volcanic plateau in northwestern Wyoming.

Along the western margin of the Absaroka Range, Yellowstone Park is famous for its fossil forests, particularly at Specimen Ridge and Amethyst Mountain. Some prostrate fossilized tree trunks have been found in this region that are more than 50 feet long and 5 feet in diameter (Sinkankas, 1959). Some amethyst has also been reported at Amethyst Mountain. Remember that collecting any specimens or rocks in any national park is illegal.

Petrified wood in the form of silicified logs, trunks, and stumps is found in many areas of northwestern Wyoming, and includes upright pieces that resemble burned-out forests. Wood casts, fossil cone casts, agatized seeds, and oval nodules are also found. These materials range in color from clear to gray to brown, yellow, green, and red with patterns that include fortifications, banding, spots, moss, tea leaf, and iris agate. Some oval nodules in this region may be remnants of chalcedony-filled vesicles in lava or scoria beds (Keenan, 1964). Wiggins Fork agates and petrified wood, as well as Yellowstone or Montana agates, are found along the Yellowstone River as far east as Glendive, Montana (Sutherland, 1990).

Ts43 and 44N, Rs107 and 108W. Horse Creek, Burrows Creek, and many other streams in this area have been reported as good collecting localities for petrified wood and agate (Cheyenne Gem and Mineral Society, 1965). The wood and agate are derived from the Wiggins Formation but some material is also found in terrace and stream gravels in this region. Volcanic material rom other than the Wiggins Formation may also contribute to the petrified vood and agates in this area. Some chalcedony may also be derived from ?aleozoic limestones (Sutherland, 1990). *Recommended map: U.S. Geolog- cal Survey topographic map of the Ramshorn 1:100,000-scale Quadrangle.*

T45N, R106W. Wiggins Fork varieties of petrified wood and agate are fairly ıbundant in the Wiggins Formation along Wiggins Fork of the Wind River ınd Frontier Creek. Note that large areas in this region are closed to collect- ng; collectors should contact the Shoshone National Forest office to obtain nformation on which areas may be open to collecting. *Recommended map: J.S. Geological Survey topographic map of the Ramshorn 1:100,000-scale Quadrangle.*

T54N, R104W. Jasperoid is reported in Paleozoic sedimentary rocks in the vestern part of this township (Nelson and others, 1980; Hausel, 1989). *Recommended map: U.S. Geological Survey topographic map of the Cody :100,000-scale Quadrangle.*

Bighorn Basin-Owl Creek Mountains

Chert, agate, and jasper occur in Paleozoic limestone along the eastern lank of the Bighorn Basin and the north side of the Owl Creek Mountains, nd in Recent gravel deposits in various drainages in this region. Woodcast gates are reported along the Bighorn River and in several drainages on he western side of the basin. Johnson (1973) reported green agate and rystal-lined geodes along Cottonwood Creek near Hamilton Dome. Petrified vood was reported a few miles north of Shell (Sutherland, 1990).

Nodular fortification agates occur along outcrops of the Phosphoria 'ormation on the southern and eastern flanks of the Pryor Mountains. The gates are most abundant just north of the state line in Montana near the onfluence of Dryhead Creek and the Bighorn River (Cheyenne Gem and Aineral Society, 1965).

Dryhead agate. A colorful red and white banded fortification-type agate, nown as the Dryhead agate, weathers out of the Phosphoria Formation n the northern Bighorn Basin (T58N, Rs94 and 95W). Some bands in his material will fluoresce green under short wavelength ultraviolet light Breitweiser, 1966). This agate is named for the barren Dryhead country eadlands, which form the cliffs along the Bighorn River just north of the Vyoming-Montana state line (Sutherland, 1990). *Recommended map: U.S. Geological Survey topographic map of the Powell 1:100,000-scale Quadrangle.*

Spanish Point. Moss agate, chalcedony, and chert are found in Paleozoic limestones near Spanish Point in sections 20, 21, 28, 29, 32, and 33, T52N, R88W (Sutherland, 1990). Root (1977) described this agate as a brown- to cream-colored moss agate. *Recommended map: U.S. Geological Survey topographic map of the Worland 1:100,000-scale Quadrangle.*

Trapper Canyon. Dendritic agates were found on the Jack No. 1 mining claim in the Trapper Canyon area (NW SW section 24, T52N, R89W) on the Trapper Galloway Ranch near Shell (Sutherland, 1990). *Recommended map: U.S. Geological Survey topographic map of the Worland 1:100,000-scale Quadrangle.*

Ts45 and 46N, Rs94 and 95W. Limb cast agates are found along the Bighorn River (Keenan, 1964; Johnson, 1973). These agates are gray to white and are similar to Wiggins Fork wood found many miles to the west in the Absaroka Range (Sutherland, 1990). *Recommended map: U.S. Geological Survey topographic map of the Thermopolis 1:100,000-scale Quadrangle.*

Black Hills

The Black Hills in northeastern Wyoming contain minor amounts of chalcedony and uncommon amethyst. In the Mineral Hill district east of Sundance, agates and jasperoids have been found in stream gravels (Hausel, 1986b). Many of these appear to be related to Tertiary alkalic volcanic rocks in the area. Farther south, some poor quality petrified wood has been reported southwest of Newcastle (Sutherland, 1990). *Recommended map: U.S. Geological Survey topographic map of the Sundance 1:100,000-scale Quadrangle.*

Artic #2 Mine. This occurrence is located in section 32, T51N, R60W, of the Mineral Hill district. Purple chalcedony with small amethyst crystals on drusy quartz was discovered in a pyroxenite at this mine, which is at the base of Mineral Hill (**Figure 81**) (W. Dan Hausel, personal field notes, 1988). The amethyst appears to be rare, but its presence suggests that other sources may occur in the district.

Black Buttes. This occurrence is located in section 26, T50N, R62W. A narrow zone of silicification in the Pahasapa Limestone (Mississippian) lies a few feet above a trachyte porphyry sill (Tertiary). Within this altered zone, a thin, reddish-brown to dark gray jasperoid with thin veins of white

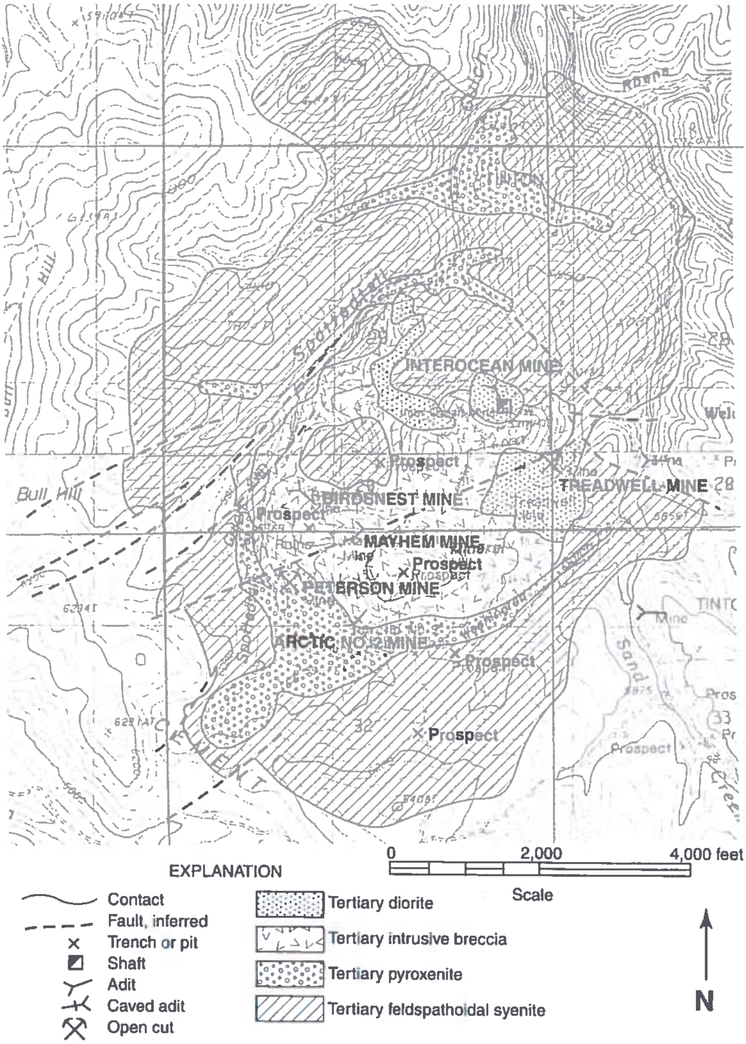


Figure 81. Generalized geologic map of the Mineral Hill district (T51N, R60W) (from Hausel, 1997).

quartz and vugs lined with quartz and white hemimorphite are found (Elwood, 1979). Locally, samples contain bright, waxy, yellow-orange specs of wulfenite, massive galena in limestone breccia, and some minor fluorite (Hausel, 1988c) (see also **ORE MINERALS**).

Mineral Hill. The Mineral Hill district is located along the South Dakota-Wyoming border northeast of Newcastle and southeast of Sundance. Access to the Mineral Hill area is by Forest Service road. Veins and pods of jasper and jasperoid are found in the Deadwood Formation (Cambrian) in a semicircular outcrop around Mineral Hill (Welch, 1974). The Deadwood Formation consists of carbonate-rich siltstones, sandstones, and flat-pebble conglomerate. The district is heavily vegetated and many rock outcrops are hidden in the brush.

Granite Mountains

The metamorphic rocks in the Barlow Gap area, Rattlesnake Hills district, and Tin Cup district are excellent places to search for chalcedony in the Granite Mountains. In addition, many of the Tertiary sedimentary rocks scattered throughout the region also contain detrital fragments of chalcedony. These are described in separate sections on Beaver Rim, Crooks Mountain, and other areas. Agates, jasper, petrified wood, gold, uranium, jade, iron, minor copper, spodumene, apatite, tourmaline, and corundum have all been found in the Granite Mountains.

One of the better known varieties of chalcedony, known as the Sweetwater moss agate, has been collected from this region for decades. Sweetwater moss agates occur as small pebbles in lag gravel and are found in the basal conglomeratic sandstone of the upper porous sandstone sequence in the Split Rock Formation (Miocene).

An Eocene unit, known as the Ice Point Conglomerate, contains rounded fragments of black petrified wood. The Bridger Formation in the same region is a source of fossil tree stumps, water worn fragments of petrified wood, and dark gray and brown agates. Agates have also been found in the Moonstone and Bug formations in this region (Love, 1970).

Clear chalcedony balls found in the region are sometimes coated with opal and white ash. These have been loosely termed moonstones (Cheyenne Gem and Mineral Society, 1965). Love (1970) produced an excellent treatise on the Granite Mountains and its mineral and rock resources. We highly recommend this publication, as it will greatly assist in finding collecting sites in the region. *Recommended maps: U.S. Geological Survey topographic maps of the Lander, Rattlesnake Hills, and Baroil 1:100,000-scale quadrangles.*

Barlow Gap

Barlow Gap. This area lies south of the Rattlesnake Hills in SW section 9, T31N, R88W. This is a great place to look for a variety of chalcedony as the area is relatively secluded and much of it is located on public land. In addition to chalcedony, the rock hound and mineral collector may enjoy searching for old 50-caliber shells, as the Barlow Gap and Rattlesnake Hills areas apparently were part of a target range for World War II fighter pilots. The history of the area also extends back to early Indian activity, as teepee rings can still be found in the Barlow Springs area.

The Barlow Gap region is underlain by Tertiary sedimentary rocks, some Tertiary alkalic volcanic rocks, and by very old Archean metamorphic rocks. The metamorphic rocks include quartzites, amphibolites, granite gneisses, mica schists, and some banded iron formation. The iron formation is a source of common jaspers and some agates. The collector should obtain a geologic map of the area and search those regions underlain by iron formation (see Sutherland and Hausel, 1999). In particular, an abundance and variety of jaspers and agates are found associated with iron formation in SW section 9, T31N, R88W. These include brown, tawny, black, red, milky, and bluish-gray agates and jaspers (W. Dan Hausel, personal field notes, 1998).

Beaver Rim area

Agates are reported on Beaver Divide, also known as Beaver Rim. This region is accessible from Jeffrey City by driving 14 miles north on the Gas Hills road. At the divide, backtrack to the southeast for 1.5 miles on a jeep trail. *Recommended maps: U.S. Geological Survey topographic maps of the Rattlesnake Hills and Lander 1:100,000-scale quadrangles.*

Cedar Rim. Fibrous chert and irregular beds of chalcedony occur in the Beaver Divide conglomerate member of the White River Formation along Beaver Divide (Love, 1970). The chert is found in section 3, T31N, R95W, a few miles south of the Big Sand Draw oil field.

Muskrat Creek. Petrified logs are reported in the east-central part of section 20, T32N, R91W, near Muskrat Creek (Bohn Dunbar, personal communication to Sutherland, 1990).

Crooks Mountain area

This area is located on the northern edge of the Great Divide Basin. *Recommended maps: U.S. Geological Survey topographic maps of the South Pass and Baroil 1:100,000-scale quadrangles.*

Bridger agates and wood. According to Love (1970), ostracod-bearing limestone, silicified green algae, fossil tree stumps, water-worn fragments of silicified wood, and dark-gray to brown agates are locally common in the Bridger Formation south of Crooks Mountain.

The Bridger Formation is exposed in the Cyclone Rim syncline (T26N, Rs96 and 97W) south of the Flattop Fault, on the Horsetrack anticline (NW part of T27N, R97W), and in a graben in the Bare Ring Butte area (sections 32 and 33, T27N, R92W). According to Love (1970), outcrops of the formation consist of "...pale-green to blue-green and lemon-yellow siliceous bentonitic claystone and shale containing thin beds of ostracod-bearing limestone and green silicified algae."

Happy Spring. The type section of the Ice Point Conglomerate is in section 3, T28N, R95W, at the site of the U.S. Coast and Geodetic Survey triangulation station ICE (VABM 7466) on the northern flank of Crooks Mountain (**Figure 60**). According to Love (1970), many rounded fragments of black petrified wood occur in the Ice Point Conglomerate. The source of the wood is unknown; however, similar petrified wood is reported in the Bridger Formation (Pipiringos, 1961).

Other areas in the Granite Mountains

Agate Flats. This area is located between Sage Hen Creek and Diamond Springs Draw in Ts30 and 31N, R90W. It has been intensely prospected during the past century for Sweetwater moss agates. Some agates may still be found in outcrop or in adjacent pediments derived from the basal conglomerate of the upper porous sandstone sequence of the Split Rock Formation in an area covering about 50 mi^2 (Love, 1970). These agates have also been reported as small pebbles in lag gravel, and in stream gravels many miles downstream (Sutherland, 1990).

Agate Lake. Very fine moss agates are reported north of the Sweetwater River in the vicinity of Agate Lake (Cheyenne Gem and Mineral Society, 1965). No legal description of this occurrence was available, and the topographic maps of the area do not show an Agate Lake.

Crooks Gap. Johnson (1973) reported agates from the Crooks Gap area in sections 29, 30, 31, and 32, T28N, R92W, south of Jeffrey City.

Dry Creek. In the SW SE section 5, T30N, R87W, a 10-foot-thick conglomeratic layer at the top of the Pliocene-Pleistocene Bug Formation in the vicinity of Dry Creek contains dark-gray and amber agates (Love, 1970). Some of these agates fluoresce yellow under ultraviolet light (Sutherland, 1990).

Rawlins Draw angel agates. A zone of chalcedony nodules, known as *angel agates*, are found in a 6-inch-thick zone in the upper porous sandstone sequence of the Split Rock Formation. The mineralized zone is about 5 feet below a 10-foot-thick pumicite marker bed in the Rawlins Draw area (SW NW section 36, T29N, R89W) north of Muddy Gap. These nodules have an attractive pale-greenish-gray color and are typically 1 to 3 inches in diameter with a chalky-white surface coating. The agates fluoresce a brilliant greenish-yellow under ultraviolet light, and are slightly radioactive (Love, 1970). The agates have been quarried for lapidary use in the past (Sutherland, 1990). *Recommended map: U.S. Geological Survey topographic map of the Baroil 1:100,000-scale Quadrangle.*

Sweeny Basin. Moss agates are found both upstream and downstream from where Highway 287 crosses the Sweetwater River in the vicinity of Sweetwater Station, Ts29 and 30N, R95W (Johnson, 1973; Bohn Dunbar, personal communication to Sutherland, 1990).

Sweetwater moss agate. This occurrence is in the NE section 16, T31N, R91W. Sweetwater moss agates are reported in the lower porous sandstone of the Split Rock Formation along the northern flank of the Granite Mountains. The agates occur as 1- to 4-inch-diameter nodules in the sandstone. The agates are radioactive and will fluoresce a brilliant yellow due to the presence of trögerite, a hydrous uranium arsenate. The agates often contain a brown, opaque surface that can be removed by tumbling. Tumbling results in a polished, light gray to blue agate with black manganese dendrites (**Figure 82, Plate 10**) (Love, 1970).

White Ridge agate beds. In section 14, T30N, R90W, agate pebble reefs and bedded chalcedony are found in the lower 500 feet of the Moonstone Formation (Pliocene). These extend eastward into the next two townships. The agates are rounded, vary from 0.25 to 0.5 inch in diameter, and crop out in low ledges over a distance of about 1 mile. The agates vary from translucent brown to gray and a few have moss-like inclusions (Love, 1970). Fossil wood is also found nearby in the Moonstone Formation (Sutherland, 1990).

Wyoming "diamonds." Within the area around Diamond Springs Draw (T31N, R90W), small, clear, quartz crystals were at one time relatively common in the Sweetwater agate beds. These have been referred to as *Wyoming diamonds*, because of their clarity, small size, and symmetrical shape (Sutherland, 1990). However, they are quartz crystals rather than diamonds.

Rattlesnake Hills

The Rattlesnake Hills district lies along the northern margin of the Granite Mountains. This terrane consists of an Archean greenstone belt fragment intruded by Tertiary alkalic igneous rocks. The area has high potential for the discovery of large-tonnage commercial gold deposits, and contains several jasperoids and breccias in vein-like deposits known as exhalites (Hausel, 1996e). Agates (**Figure 83, Plate 10**) are also found in the pediment gravels along the southern margin of the district. *Recommended map: U.S. Geological Survey topographic map of the Rattlesnake Hills 1:100,000-scale Quadrangle.*

Lost Muffler. This occurrence is in SW section 16, SE section 17, NE section 21, and NW section 22, T32N, R87W. The Lost Muffler mineralized zone was mapped by Hausel (1996e) along UT Creek (**Figure 61**). This mineralized zone consists of a cherty unit associated with jasperoid, quartz, graphitic schist, and local pyrite, minor galena, and arsenopyrite.

Jasper Knobs. Two hills on either side of the Dry Creek Road in W/2 NW section 35, T32N, R88W, lie along a north-south trend on the southern edge of the Rattlesnake Hills. These two hills are covered with banded golden brown and red jasper in limestone (Hank Hudspeth, Jr., personal communication to Sutherland, 1989). Some uncommon specimens of jasper with fossil leaf imprints are found here (W. Dan Hausel, personal field notes, 1999). The jasper is massive, and covers an area of about 10 acres. The outcrop forming the hill on the north side of the Dry Creek road is a deep blood-red and is easily spotted from the road. The deposit is interbedded in a limy rock, and may represent a paleo hot spring. *Recommended map: U.S. Geological Survey topographic map of the Barlow Gap 1:24,000-scale Quadrangle.*

Other jasper/agate deposits in T32N, R88W. Several other jasper and agate deposits are found in the Barlow Gap-Rattlesnake Hills area, but are much smaller than the Jasper Knobs. These include red and brown jasper along a shear zone in SE NW section 34, T32N, R88W, and a small pod of red and brown jasper in Precambrian host rock on the south side of a breccia zone in NE SW section 26, T32N, R88W. In addition, pale yellow, gray, and white layered agates in rough slabs up to 4 inches thick and 10 inches long are found along the east side of a ridge in NE SE section 15, T32N, R88W (Wayne M. Sutherland, personal field notes, 1999).

Tin Cup district

The Tin Cup district in the western Granite Mountains is underlain by amphibolite-grade metamorphosed Archean gneiss, schist, and amphibolite intruded by granite. The northern part of the district includes three prominent faults with a total strike length of nearly 7 miles and scattered outcrops of jasper (**Figure 30**). A few mines were developed along the southernmost fault in search for gold in the 1800s, including the Red Boy and Sutherland mines. Apparently no gold was found, but some massive sulfide (pyrite) was intersected in the mine workings.

Recent investigations by Hausel (1996c,d) described ruby, sapphire, jade, and jasper in the district. *Recommended map: U.S. Geological Survey topographic map of the Rattlesnake Hills 1:100,000-scale Quadrangle.*

Sutherland-Red Boy mines. This area is in sections 25 and 36, T31N, R93W. The Sutherland shaft was sunk in a gossan and intersected massive pyrite at a shallow depth. Samples of massive pyrite and banded gneiss with stratiform pyrite can be found on the mine dump. In addition, beautiful specimens of jasperized breccia are found in a mine adit driven on the same structure a short distance northeast of the shaft. The breccia contains angular fragments of blood-red, chocolate-brown, and butterscotch-yellow-brown jasper with minor agate in a granular matrix.

Approximately 1000 feet to the southwest along the same structure, quartz-rich schist and jasper were found on a dump from an adit estimated to be about 50 feet in length (W. Dan Hausel, personal field notes, 1995). Even farther southwest, about 2500 feet from the Sutherland shaft, some copper-stained jasper with minor malachite, azurite, and tenorite with a trace of chalcocite was found (Hausel 1996c).

Tin Cup Mountain. This area is in sections 24 through 27, T31N, R93W, and section 19, T31N, R92W. North of the Sutherland-Red Boy structure, jasperoids are found in two parallel faults (**Figure 30**). Beautiful red jaspers with jasperoid breccias and gray, banded, isoclinally folded agates were found along a 3- to 4-mile-long fault. Common massive jasper with jasperoid breccia was also found in the W/2 section 27, T31N, R93W. Other beautiful specimens of red jasper and gray and white banded jasperoid (agate) were found in several of the prospects along all three faults.

The agates and jaspers from this area produce exquisite pieces of polished rock. In particular, beautiful specimens of folded agate and red to butterscotch jasper were collected from prospects in section 24, T31N, R93W, and section 19, T31N, R92W (Hausel, 1996c).

S/2 S/2 SE section 25, T31N, R93W. A prospect pit located along trend between the Sutherland and Red Boy mines contains dump material with quartz, opalized quartz, and jasperoidal hematite. The jasper is also found in place between sheared amphibolite and hematitic schist (W. Dan Hausel, personal field notes, 1995).

W/2 NW section 25, T31N, R93W. A shallow shaft contains minor quartz and jasper on the mine dump. This prospect lies on a fault north of and parallel to the Sutherland-Red Boy structure (W. Dan Hausel, personal field notes, 1995).

The Greater Green River Basin of southwestern Wyoming includes the Great Divide, Washakie, and Green River basins. Petrified wood of the Eden Valley type, petrified algae, and *Goniobasis* agate (**Figure 84**) are all found in this part of the state. Some jasperoids are also found on Aspen Mountain (or Quaking Asp Mountain), and black flint and agate are associated with some buttes in the basin, including Black Buttes and Aspen Mountain.

Figure 84. Goniobasis agate from the Delaney Rim area, Red Desert.

Many miles north of Aspen Mountain, Eden Valley petrified wood is found over a wide area centered around Farson. This petrified wood resembles ordinary weathered wood and has an opaque, cream-colored outer coating of silica over a core that varies from black to brown and gray, with gray streaks in darker specimens. Most of the material is smaller than a few inches in diameter and less than a foot in length (Sutherland, 1990).

Some specimens of the wood have been incompletely silicified. When these are exposed to weathering for long periods of time, the wood may loose its ability to take a high polish (Cheyenne Gem and Mineral Society, 1965). Because of this, lapidaries tend to search for choice quality material in recent exposures caused by erosion or dig below the ground surface to find material.

The source of all the above material appears to be the Laney Shale Member, which is the uppermost member of the Green River Formation, and the overlying Bridger Formation, both of Eocene age. During deposition of the Laney sediments, which now consist of tuffaceous, buff, chalky to muddy marlstone and brown to gray shale, the climate was warm and moist. Under these conditions hardwood trees, pine, fir, magnolia, and other types of trees flourished in widespread heavily forested swampland cut by numerous braided streams. A large, inland freshwater lake known as Lake Gosiute (which at times covered a large area of southwestern Wyoming, northwestern Colorado, and northeastern Utah) expanded and contracted in response to periods of increased precipitation followed by dry periods. The fluctuation in the lake level alternately allowed expansion of the forests around the lake, or drowned the timber as the lake rose. The drowned timber was gradually buried in lake sediments and showers of volcanic ash. Over time, the wood became petrified from silica leached from the volcanic material. Later erosion exposed the silicified wood, silicified algae, oolitic limestones, and layers of *Goniobasis* snail shells (Bradley, 1964).

The overlying Bridger Formation is primarily fluviatile with some thin lacustrine layers. Locally the formation contains silicified limestones and marlstones. Petrified wood is common in the Bridger Formation, particularly in the vicinity of Oregon Buttes (Bradley, 1964). Much of the wood is encrusted with algae and was silicified by processes similar to those that petrified materials in the underlying Laney Shale. According to the Cheyenne Gem and Mineral Society (1965), this wood, known as the Bridger-type, consists of partially silicified, black petrified wood. It includes limbs, trunks, stumps, and roots. Where the wood is completely replaced by silica, it ranges in color from brown to tan to green. In addition to the wood, some clear chalcedony and vein moss agates are found in this region.

Reefs and beds of silicified *Goniobasis* gastropods, which were deposited only at certain depths within Lake Gosiute, are found throughout the lake's area. Not all occurrences of *Goniobasis* were equally silicified. Some *Goniobasis* agates that are light-brown in color with a weathered appearance do not take a good polish. Dark brown to black shades typically will polish, and this material is sought by rock hounds.

Big Sandy Reservoir. Some Eden Valley petrified wood is found in T27N, Rs105 to 106W, north of Farson and northeast of the Big Sandy Reservoir (Cheyenne Gem and Mineral Society, 1965). According to Gems and Minerals Magazine (July, 1976), some collecting localities for petrified wood and algae are located 1 to 2 miles east and north of the reservoir. *Recommended map: U.S. Geological Survey topographic map of the Farson 1:100,000-scale Quadrangle.*

Black Butte. Gray to black flint and chert occur on Black Butte south of Point of Rocks in sections 4 and 9, T18N, R101W (Hausel and others, 1995). Black Butte is capped by silicified Erickson Sandstone (Upper Cretaceous). Similar specimens of chert have been found elsewhere in the Greater Green River Basin. In particular, chert caps many sedimentary buttes in the basin since it acts as a layer resistant to erosion, thereby protecting the underlying sedimentary rocks. *Recommended map: U.S. Geological Survey topographic map of the Red Desert Basin 1:100,000-scale Quadrangle.*

Blue beds petrified wood. The Cheyenne Gem and Mineral Society (1965) described the south half of T23N, R109W, as a source for several types of petrified wood, which are found in the "blue beds" that cover much of the area. These "blue beds" appear to be within the Bridger Formation (Sutherland, 1990), and are located a short distance southeast of the Blue Forest agate area. *Recommended map: U.S. Geological Survey topographic map of the Rock Springs 1:100,000-scale Quadrangle.*

Blue Forest agate. Petrified wood found in sections 28 through 33, T24N, R110W, has a black to brown central core surrounded by clear blue chalcedony, producing a unique and very attractive silicified wood (**Figure 85, Plate 10**) (Eloxite Corporation, 1971).

Within this same area, small clear symmetrical quartz crystals erroneously termed "Wyoming diamonds," have been found. These are similar to the quartz crystals found in the Sweetwater agate beds of the Granite Mountains (Sutherland, 1990). *Recommended map: U.S. Geological Survey topographic map of the Farson 1:100,000-scale Quadrangle.*

Cedar Mountain area. The Cedar Mountain area offers an attractive place to collect rock and mineral specimens. The area is located in an isolated region near the Utah border north of the Uinta Mountains near Lonetree. Several varieties of chalcedony are found here. Beautiful pyrope garnet, emerald-green chromian diopside, and enstatite, are also found in this region, primarily in anthills on the Bridger Formation, the Bishop Conglomerate, and in a cluster of breccia pipes of kimberlitic affinity. *Recommended maps: U.S. Geological Survey topographic maps of the Firehole Canyon and Evanston 1:100,000-scale quadrangles.*

Along the eastern flank of Cedar Mountain (sections 2 and 19, T14N, R110W; sections 22, 24, and 25, T14N, R111W; and section 23, T15N, R111W), Mitchell (1984) reported several varieties of chalcedony associated with the Bridger Formation. Agate, jasper, jasp-agate, flint, chert, and zebra flint (white, brown, and black striped flint) were found. Some of the material may be derived from the Bishop Conglomerate (Oligocene) which caps Cedar Mountain on the west and south. The jasp-agate in this region is red and yellow with white and blue streaks. The jasper is bright orange and yellow. Agates are multicolored to black with moss, flame, and plume patterns (Sutherland, 1990).

West of Cedar Mountain, outcrops of white beds in the Bridger Formation in the west-central and northwestern part of T13N, R113W, exhibit occasional irregular bands of black and brown chert (Bradley, 1964). Along the western margin of the township (section 19, T13N, R113W), Madsen (1983) reported silicified gastropods in the Bridger Formation. To the north in the vicinity of Leavitt Creek, Madsen also reported finding silicified algae mats as well as a fossilized turtle shell nearby.

Along the northeastern flank of Cedar Mountain (T15N, Rs111 and 112W), agates, chert, and jasper are found in soils derived from the Bridger Formation. Some of the better collecting areas are found near the center of these townships (W. Dan Hausel, personal field notes, 1988).

Cumberland Flats. Some agate and petrified wood is reported in the Cumberland Flats area (T19N, R117W) south of Kemmerer (Johnson, 1973).

Recommended map: U.S. Geological Survey topographic map of the Kemmerer 1:100,000-scale Quadrangle.

Fourmile Gulch. Exposures of the Bridger Formation in sections 2, 3, 8, 9, 15, and 16, T23N, R110W, and sections 34 and 35, T24N, R110W, are reported by Mitchell (1982) to yield several varieties of chalcedony. These include yellow and brown jasper and petrified wood. Some of the wood and agates have a blue color, but the majority of the agates are multicolored. *Recommended map: U.S. Geological Survey topographic map of the Rock Springs 1:100,000-scale Quadrangle.*

Granger area. Large concretions, known locally as geyser pipes (**Figure 86a, Plate 10**), contain open spaces filled with quartz and calcite crystals (**Figure 86b, Plate 10**). These rocks are found on buttes northeast of Granger in Ts19 and 20N, Rs110 and 111W (Carolyn Jones, personal communication, 1996). Some of the concretions weigh several hundred pounds.

Hams Fork. Abundant agate is found in the badlands along the Hams Fork in T20N, Rs112 and 113W; and T21N, Rs112 through 114W. This area is underlain by extensive areas of Bridger Formation and the Laney Shale Member of the Green River Formation (Cheyenne Gem and Mineral Society, 1965; Sinkankas, 1959). *Recommended map: U.S. Geological Survey topographic map of the Kemmerer 1:100,000-scale Quadrangle.*

Jack Morrow Hills. Eden Valley petrified wood has been collected in the area of the Hay Ranch (sections 1, 2, 11, and 12, T25N, R103W) in the Jack Morrow Hills (Cheyenne Gem and Mineral Society, 1965). *Recommended map: U.S. Geological Survey topographic map of the Farson 1:100,000-scale Quadrangle.*

Little America region. *Goniobasis* agate and some silicified algae reportedly cap some buttes between Green River and Granger in Ts18 and 19N, Rs108 through 111W (Hausel, 1986b; Sinkankas, 1959). The agate layers typically are found within the Laney Shale and the overlying Bridger Formation (Sutherland, 1990). *Recommended map: U.S. Geological Survey topographic map of the Rock Springs 1:100,000-scale Quadrangle.*

Lyman. Moss Agate Cut lies on the Bridger Formation in section 1, T16N, R114W. The source of the place name is unknown.

Moss Agate Knoll. This locality (section 1, T18N, R112W) is known as Moss Agate Knoll and includes outcrops of the Bridger Formation. *Recommended map: U.S. Geological Survey topographic map of the Kemmerer 1:100,000-scale Quadrangle.*

Oregon Buttes. An area east of Oregon Buttes in Ts26 and 27N, Rs100 and 101W, is a source for much of the Eden Valley petrified wood (Sinkankas, 1959; Eloxite Corporation, 1971). The characteristic dark petrified wood found in this area is probably from either the Laney Shale Member of the Green River Formation or the overlying Bridger Formation.

Oregon Buttes is the easternmost region from which large quantities of Eden Valley petrified wood have been reported. Bradley (1964) described petrified wood as a common occurrence in the Bridger Formation, particularly in the vicinity of Oregon Buttes. He also reported silicified algal and oolitic limestone from the Laney in section 2, T26N, R101W.

The area around Oregon Buttes is also a good place to search for gold, as considerable gold has been found in the region (Love and others, 1978). *Recommended map: U.S. Geological Survey topographic map of the South Pass 1:100,000-scale Quadrangle.*

Quaking Asp Mountain. Banded jasperoids were discovered on Quaking Asp Mountain (also known as Aspen Mountain) south of Rock Springs in NW section 22, T17N, R104W (Hausel, Marlatt, and others, 1995). The area contains some unusual rocks and minerals, including alunite, travertine, free sulfur, silicified breccia, kaolinite, and jasperoid. These are found within a 20 to 30 mi^2 silicified zone.

The mountain is capped by a fine- to medium-grained sandstone (and quartzite) of the Rock Springs Formation (Upper Cretaceous), which is underlain by highly silicified, gray, silty and sandy shale interbedded with gray siltstone and fine-grained sandstone of the Blair Formation (Upper Cretaceous). These rocks are unconformably overlain by a sandstone facies of the Bishop Conglomerate. The jasperoids found near the top of Aspen Mountain consist of dark- to light-gray banded agate with cross-cutting veins of quartz, and banded red, yellow-orange, and gray onyx-like jasperoid (**Figure 87, Plate 10**). *Recommended map: U.S. Geological Survey topographic map of the Firehole Canyon 1:100,000-scale Quadrangle.*

Sublettes Flat. This occurrence is located west of Big Sandy Reservoir in Ts26 and 27N, R107W. The area hosts small limb casts of milky-white agate. The agates occasionally contain an internal tube-like structure and may exhibit an iris agate color display (Cheyenne Gem and Mineral Society, 1965). *Recommended map: U.S. Geological Survey topographic map of the Farson 1:100,000-scale Quadrangle.*

Whiskey Basin. Johnson (1973) reported petrified wood and agate in the Whiskey Basin area (T21N, R111W). This area is underlain by the Bridger Formation and has had a long history of discoveries of petrified wood and other forms of chalcedony (**Figure 88**). *Recommended map: U.S. Geological Survey topographic map of the Rock Springs 1:100,000-scale Quadrangle.*

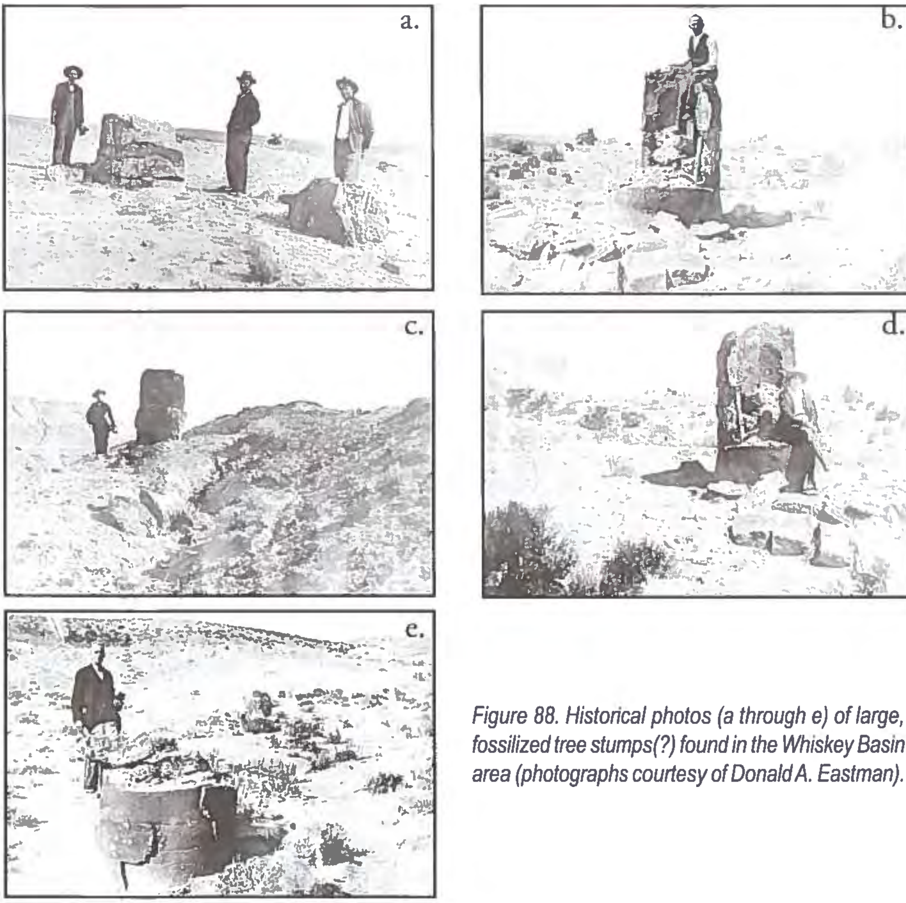


Figure 88. Historical photos (a through e) of large, fossilized tree stumps(?) found in the Whiskey Basin area (photographs courtesy of Donald A. Eastman).

Hartville uplift

The Hartville uplift in southeastern Wyoming is a favorite collecting locality for many rock hounds and private collectors (**Figure 13**). The uplift is enclosed by a core of Archean eugeoclinal metasedimentary and metavolcanic rocks, with overlying Paleozoic sedimentary rocks that dip off the flank of the uplifted core. *Recommended maps: U.S. Geological Survey topographic maps of the Lusk and Torrington 1:100,000-scale quadrangles.*

Within the uplift, chalcedony is found in sedimentary rocks and in some veins. Multicolored, cryptocrystalline silica, mainly jasper, has been found in association with fractures and faults. The Guernsey Limestone (Devonian-Mississippian) is a source of many agates and jaspers in the district, including red, purple, brown, and yellow jasper, as well as moss agate, stalactitic agate, and youngite agate. Much of the collectable material occurs as float; however, some is found as nodules, seams, and fracture fillings in the Guernsey Limestone. The Hartville Formation (Pennsylvanian-Permian) is also a source of jasper and fortification agate (**Figure 89, Plate 11**) (Sutherland, 1990).

Other attractive ornamental stones were described by the U.S. Geological Survey (1908), including an attractive ornamental stone of blue quartz consisting of a brilliant coating of quartz crystals over blue to greenish-blue copper minerals (fibrous malachite with blue chrysocolla, on a pale-blue cupriferous allophane?) on hematite. This was reported at the Sunrise iron mine. Large masses of black dendritic agate weighing up to 50 pounds with white coatings (Slater agate?) were also reported in limestone. Some table tops were manufactured from this agate and exhibited at the World's Columbian Exhibition in the late 1800s (U.S. Geological Survey, 1893).

Adams Hartville agate mine. The Adams Hartville agate mine is located a short distance north of the town of Guernsey near the top of a hill in the center of section 25, T27N, R66W (Eloxite Corporation, 1971). This appears to be the same location given for the Wilde and Deercorne mine (U.S. Geological Survey, 1908). Most of the moss agate produced from the Hartville area was from this mine. The U.S. Geological Survey (1908) indicated that 2 tons of moss agate were produced in 1893, more than 7 tons in 1903, and 3.5 tons in 1908.

The agate varies from clear to white with black dendritic moss-like inclusions, and fluoresces bright green under ultraviolet light. At this locality, the Guernsey Limestone (Devonian and Mississippian) contains some lower quartzite beds and rests unconformably on Precambrian (Archean) quartzites, phyllites, and schists (U.S. Geological Survey, 1908).

Moss agate mined around the turn of the century was recovered from an irregular vein that varied from 1 inch to 2 feet in thickness and cross cut the Guernsey Limestone. Red banded agate has also been reported at this locality. About 200 yards north of the mine, some copper prospects were reported by Eloxite Corporation (1971) to contain brown jasper with bright blue streaks of chrysocolla.

Bassite. An attractive breccia formed of tan to light-gray limestone clasts cemented by red, pink, and purple chalcedony is found on the Gene Bass Ranch (Norma Beers, personal communication, date unknown). No location is given.

Charter Oak mine. Samples collected from the Charter Oak mine in NE section 26, T28N, R65W, included some jasperoid, as well as arsenopyrite, pyritized graphitic schist, and massive sulfide (W. Dan Hausel, personal field notes, 1988). A few samples also contained malachite, chrysocolla, and chalcocite (Hausel, 1997a).

Glendo Reservoir. Several varieties of agate and jasper can be found on the shores of Glendo Reservoir and in the surrounding country (T30N, Rs67 and 68W) (Hayford, 1971; Eloxite Corporation, 1971). These include a golden brecciated jasper; white stalactitic agate; red, pink, and white scenic seam (irregularly banded) agate; polka-dot agate; black moss agate; and butterscotch agate. The source for these materials is believed to be the Hartville Formation and Guernsey Limestone (Sutherland, 1990).

Guernsey Reservoir. The shores and cliffs surrounding Guernsey Reservoir exhibit several varieties of chert and chalcedony that are often found as detrital material near the lake (sections 6 through 10, 15 through 22, 26, and 27, T27N, R66W; and sections 1, 12, and 13, T27N, R67W). These include red and purple jasper, youngite (**Figure 90, Plate 11** and **front cover**), and some fortification agates (Hayford, 1971).

Guernsey youngite cave. A cave in Guernsey Limestone along the edge of the North Platte River is lined with youngite agate. This cave is located on state land (SE W/2 W/2 section 36, T28N, R67W); access and entry to the cave may be limited. The 10-foot-high entrance to the cave, which in the past was accessed from above by wooden ladders, is located at the base of a 100-foot-high cliff overlooking the Platte River.

The cave extends horizontally into the Guernsey Limestone for 600 to 1000 feet, and ranges in height from 1 to 15 feet. Much of the cave ribs and back are encrusted with pink to purple and gray youngite agate (named after a Dr. Young from Torrington). The cave is noteworthy because of its almost complete lining with silica. Veins and float material are found in several areas within section 36. Sutherland (1985) suggested that the silica was derived from leaching the formerly overlying tuffaceous rocks of the Oligocene White River Formation.

Hell Gap. East of Hell Gap, in section 14, T28N, R65W, 3- to 5-foot-wide veins containing jasper have been traced 850 feet along trend (Millgate, 1965).

McCann Pass. Jasper and jasperoid are found in the McCann Pass area in N/2 NE section 26, T28N, R65W (see also ***Charter Oak mine***) (W. Dan Hausel, personal field notes, 1988).

North Platte River. Youngite is reported along the northern bank of the North Platte River north of Guernsey Reservoir in section 36, T28N, R67W.

Page Flat. Youngite is reported in the Page Flat area in N/2 and SW NE section 36, T32N, R65W (Ray E. Harris, personal communication to Sutherland, 1990).

Rocky Pass. Northwest of Hartville, in NE section 2, T27N, R66W, moss agates similar to Sweetwater moss agates are found as float on the hill above the Hartville marble-onyx prospect. Some jasper is also present near the prospect (Eloxite Corporation, 1971).

Sawmill Canyon. This occurrence is in SW NE NW section 22, T28N, R67W. Youngite is found on the southeast-facing slope on the north side of the canyon (Sutherland, 1990).

Spanish Diggings. Fortification agates are reported in the vicinity of the Spanish Diggings in Ts30 and 31N, Rs66 and 67W (Eloxite Corporation, 1971). An orthoquartzite above the Morrison Formation (Jurassic) was once a local source for stone tools and weapons for Indians (Sutherland, 1990).

Section 6, T27N, R64W and NE section 36, T28N, R65W. Some jasper, associated with faulting, is reported east of Garnet Hill. The jasper is porous and in the southeastern exposures, the jasper contains rare, small molybdenite flakes (Millgate, 1965).

NW section 13, T27N, R66W. During field investigations in this area, samples of chrysocolla, banded chert, and jasper were found on a prospect pit dump. Common jasper and agate float were also found in the adjacent drainage. In this same area, umangite (Cu_3Se_2) was reported by Kerr-McGee Corporation. Prospect pits in the area are located along an unconformity between Pre-

Cambrian dolomite and overlying Phanerozoic carbonate and conglomerate (W. Dan Hausel, personal field notes, 1988).

NW section 24, T27N, R66W. Agate and jasper float are found east of Hartville Canyon (W. Dan Hausel, personal field notes, 1988).

NW section 5 and NE section 6, T28N, R65W. Brown chert nodules up to 1 foot in diameter associated with the Hartville Formation are found in the nearby hills. When cut, these agate nodules exhibit colorful fortifications in bands colored red to brown, white, gray, and clear (Ray E. Harris, personal communication to Sutherland, 1990).

Sections 6 and 7, T30N, R65W. Jasper is found in the Hartville Formation along the line separating the two sections (Ray E. Harris, personal communication to Sutherland, 1990).

Sections 28, 33, and 34, T32N, R69W. Veins containing chalcedony with some associated uranium were reported by Guilinger (1956) in steeply dipping, northeast-trending fault zones in the White River Formation (Oligocene). The chalcedony was reportedly radioactive, and exhibited yellow-green fluorescence under short-wavelength ultraviolet light. J.W. Gruner (unpublished field notes, University of Minnesota, 1955) noted that silicified fault zones in the southern part of the township formed discontinuous sharp ridges up to 30 feet wide. Some of these faults were reported to contain quartz as well as opal.

Laramie Mountains

The following eight occurrences of chalcedony in the Laramie Mountains can be located by using U.S. Geological Survey topographic maps of the Douglas, Casper, Rock River, and Laramie 1:100,000-scale quadrangles.

Box Elder Canyon. This occurrence is located southeast of Glenrock near State Highway 90 in sections 6 and 7, T32N, R74W, and sections 1 and 12, T32N, R75W. Layers of chalcedony and crystalline quartz have been reported in geodes in sandstones and limy sandstones (Osterwald and others, 1966; Hayden, 1871).

Casper Mountain. Smoky quartz is reported in Precambrian pegmatite dikes on Casper Mountain in sections 17 through 20, T32N, R79W (Harris and Hausel, 1986). In addition to the quartz, many of these pegmatites also contain rare to common, opaque beryl crystals.

Duck Creek. This occurrence is in sections 4, 5, and 6, T23N, R71W, and sections 35 and 36, T24N, R72W. Tiny amethyst crystals (less than 1 mm in length) were found in stream sediment concentrates during a diamond exploration project by the Wyoming State Geological Survey (Hausel and others, 1988). The nature of the study precluded recovery of any larger material; however, these small crystals suggest there is a source for amethyst upstream.

Hay Canyon. Steeply dipping Paleozoic limestones along the east limb of Hay Canyon syncline (W/2 section 18, T19N, R70W) contain numerous agate and jasper replacements. These nodules range from red to gray to green and typically are a few inches to several inches across. Some of the agates are highly fractured, others are coherent fragments (W. Dan Hausel, personal field notes, 1998).

Moss Agate Hill. Moss Agate Hill in section 23, T31N, R74W, adjacent to Moss Agate Creek southwest of Douglas, has been a source of moss agate in past years. However, the hill has been essentially picked clean, and agates are now difficult to find (Osterwald and others, 1966).

Pinto Creek. Attractive purple to light-blue chalcedony, agate, and botryoidal agate with a white crust are reported in the Pinto Creek area (sections 35 and 36, T24N, R74W) (**Figure 91, Plate 11**) (Norma Beers, personal communication, date unknown).

South Cooney Hills. Massive white bull quartz occurs in several pod-like veins in the east half of section 19, T23N, R69W, in the South Cooney Hills. The quartz is unimpressive in hand specimen, but has extraordinary piezoelectric properties. By striking the quartz with a hammer, a noticeable electric spark is generated within the quartz that is quite visible in a darkened room. Some rose quartz is also found in the area, but with a less developed piezoelectric display (Ray E. Harris, personal communication to Sutherland, 1989).

State Line district. Some uncommon, well-formed prismatic iron-stained translucent quartz crystals have been found in Precambrian pegmatites in section 2, T12N, R72W, near U.S. Highway 287 south of Tie Siding (Hausel, 1986). Several of the pegmatites in this area were quarried for feldspar during the 1940s.

Leucite Hills

Steamboat Mountain. Agate and chalcedony were found in sections 9, 10, 11, 15, and 16, T23N, R102W, on the slopes of Steamboat Mountain north of Superior, Wyoming (Sinkankas, 1959). Wilson (1965) further described the material as chalcedony-lined amygdules ranging in length from 3 to 6 inches. The amygdules occur within the vesicular phlogopite lamproite lava flows surrounding the Steamboat Mountain cinder cones. *Recommended map: U.S. Geological Survey topographic map of the Red Desert Basin 1:100,000-scale Quadrangle.*

Medicine Bow Mountains

There are three chalcedony localities of interest in the Medicine Bow Mountains. *Recommended map: U.S. Geological Survey topographic map of the Saratoga 1:100,000-scale Quadrangle.*

New Rambler district. This occurrence is located in section 1, T14N, R79W, and section 6, T14N, R78W. A fault trending northeasterly through the New Rambler district is marked by a narrow breccia zone. The breccia contains abundant, irregularly shaped masses of blue-gray to white opaline chalcedony. At the New Rambler mine to the west (SW section 33, T15N, R79W), copper was intersected at shallow depths by a shaft that also exposed some "jaspilite." The New Rambler mine is known for its variety of copper minerals and rare platinum mineralization (see **ORE MINERALS**) (McCallum and Orback, 1968).

Rock Creek headwaters. Clear quartz crystals up to 1.5 inches in length and 0.5 inch in diameter have been reported as isolated float in section 31, T17N, R78W (Sutherland, 1990). The source of the quartz has not been identified.

Sheep Mountain. Large, log-like concretions weather out from the Sundance Formation (Jurassic) along the western flank of Sheep Mountain in sections 5 and 8, T14N, R77W, and sections 20, 29, and 32, T15N, R77W. Osterwald and others (1966) reported that the concretions contained small amounts of low-quality amethyst.

The Powder River Basin contains several varieties of chalcedony (including petrified wood, chert, and jasper) associated with Paleozoic limestones and Tertiary strata along the eastern flank of the Bighorn Mountains (Hausel and others, 1990). Moss agates are also reported between Fort Reno and Crazy Woman Creek (Cheyenne Gem and Mineral Society, 1965). *Recommended maps: U.S. Geological Survey topographic maps of the Buffalo, Casper, and Douglas 1:100,000-scale quadrangles.*

The majority of the petrified wood found in the basin occurs in the Wasatch Formation (Eocene). Occasionally, some spectacular, large-diameter stumps and logs are found, such as the wood located east of Buffalo at BLM's Dry Creek Petrified Tree site. Although occasionally impressive, this wood is typically poorly silicified, brittle, and easily crumbles into small pieces that are not suitable for tumble polishing.

The Crazy Woman Creek petrified wood is more durable and well-suited for lapidary purposes. This wood is well silicified, banded in shades of brown and white, and is found in terrace gravels about 60 to 120 feet above Crazy Woman Creek in an area extending from the flank of the Bighorn Mountains to the intersection of Dry Creek with Crazy Woman Creek.

Large pieces of the Crazy Woman petrified wood, up to 18 inches in diameter and 16 inches long, have been collected from the vicinity of Crazy Woman Creek and can now be found in landscaping and in local collections in Buffalo. Similar material has been found in terrace gravels along the Powder River near Kaycee (Sutherland, 1990).

Crazy Woman Creek petrified wood. This occurrence is in S/2 section 24 and NE section 31, T48N, R81W. Partially rounded cobbles of Crazy Woman Creek petrified wood ranging in length from 3 inches to more than 10 inches have been found in piles of oversize material in a gravel pit in section 24. Chunks of the wood up to 6 inches in length have been found near an old gravel pit in section 31 (Sutherland, 1990).

McNeese Draw. Numerous poorly silicified petrified trees and logs are found in sections 30 and 31, T51N, R80W, between the Healy and Walters clinker/coal beds in the Wasatch Formation (Eocene). The BLM maintains a withdrawn area in section 31 to allow visitors to see some impressive early Eocene petrified forest remains. Durkin (1986) identified these trees as cypress and sequoia. Some specimens as tall as 12 feet, and 3 feet or more in diameter, have been found in this area.

Poison Spider. Carnelian is reported between Poison Spider and South Casper creeks west of Casper (Osterwald and others, 1966). Aughey (1886) and the Cheyenne Gem and Mineral Society (1965) reported chrysoprase was also found north of Poison Spider Creek.

Shawnee Creek area. Fault zones east of Douglas in section 28, T32N, R69W, contain some quartz, chalcedony, and opal (J.W. Gruner, unpublished field notes, University of Minnesota, 1955) (see also **OPAL**).

T51N, Rs80 and 81W. Zeitner (1969) reported some amethyst-lined cavities in specimens of petrified wood east of Buffalo.

Rawlins uplift

Cold Spring Draw. There is one reported occurrence of agate in the Rawlins uplift. Carnelian agate is found in sections 9, 10, 15, 16, 21, and 22, T22N, R88W, in the vicinity of the headwaters of Cold Spring Draw north of Rawlins. The host for the agate is unknown (Harrison Cobb, personal communication to Sutherland, 1988). *Recommended map: U.S. Geological Survey topographic map of the Rawlins 1:100,000-scale Quadrangle.*

Seminoe Mountains

The Seminoe Mountains are primarily known for gold veins and extensive banded iron formation; however, some cobbles and pebbles of jasperized banded iron formation are commonly found in the area, particularly in the Deweese Creek valley and in paleoplacers along the northern flank of the Seminoe Mountains. *Recommended map: U.S. Geological Survey topographic map of the Shirley Basin 1:100,000-scale Quadrangle.*

Bradley Peak-Deweese Creek. Jasperized banded iron formation is found along the Deweese Creek valley north of Bradley Peak and in unconsolidated conglomerates and colluvium extending from Deweese Creek east to the North Platte River (Hausel, 1994b). The jasperized iron formation is magnetic and consists of alternating bands of black magnetite, dark gray quartz, and tawny to brown layers of jasper and grunerite (**Figure 92, Plate 11**). This material has also been called taconite, jaspilite, and ironstone. Pebbles of the same material have also been found a few miles east in the Miracle Mile area along the North Platte River. This area includes sections 5, 6, 7, 8, and 18, T26N, R85W. The Miracle Mile is surrounded by a dry placer formed of unconsolidated gravels located several feet above the river banks. Gold colors and pyrope garnets have also been recovered from the dry placer on both sides of the North Platte River.

Shirley Basin-Shirley Mountains

Shirley Basin is a Tertiary basin flanked by the Laramie Mountains along its eastern and northern flanks and the Shirley Mountains to the southwest and south. This basin is the source of several agates and jaspers, most of which have been derived from Casper Formation limestones and sandstones along the eastern margin of the basin. The basin was once known as a source of petrified logs; logs 3 to 4 feet in diameter were recovered in the 1930s to 1950s. In addition to fossil forests, the Como Bluff anticline along the southern margin of the basin was a world-class source of silicified dinosaur bones in the past. Some dinosaur collecting activity continues in the area to this day. *Recommended maps: U.S. Geological Survey topographic maps of the Casper, Laramie Peak, Medicine Bow, and Shirley Basin 1:100,000-scale quadrangles.*

Agate Basin. Agate Basin is located in sections 18 and 19, T30N, R83W, on Oligocene White River Formation 3 miles northwest of Alcova Reservoir (Sutherland, 1990). No other information is available.

Boot Heel. Several pieces of fossilized wood and tree stumps have been found on Boot Heel in section 22, T26N, R77W (Nat Smith, personal communication, 1997). A circular topographic depression in this area was investigated by the WSGS, but the origin of the feature was not determined. It does contain abundant yellow, red, gray, black, and banded agate and jasper (W.D. Hausel, personal field notes, 1997).

Como Bluff. Silicified dinosaur bones have been found on both flanks of Como Bluff anticline (T22N, R77W), north of U.S. Highway 287/30 near Medicine Bow (Sinkankas, 1959). A cabin constructed from some of the silicified bones lies adjacent to the highway. The Cheyenne Gem and Mineral Society (1965) reported that agatized wood fragments are also found on both flanks of the anticline.

Marshall. A diverse variety of agates are found in Ts26 and 27N, R75W, near Marshall in the eastern part of Shirley Basin. These include white moss, plume, and black agate, jasp-agate, and other agates derived from limestones in the Casper Formation (Sutherland, 1990).

Mine Hills. A reddish-brown jasper mixed with dark gray to black opaque agatized breccia is found in the Mine Hills and Crystal Hill area (section 10, T26N, R75W) south of Marshall (**Figure 11**). This rock consists of pink breccia clasts of Casper Formation sandstone cemented with reddish-brown and massive black chert and coated with small grains of psilomelane (a metallic, manganese oxide). The psilomelane sparkles in sunlight. Some agates from the area will fluoresce green under short- and long-wavelength ultraviolet light.

Moss Agate Reservoir. Moss Agate Reservoir in section 32, T28N, R78W, is underlain by the Wind River Formation (Eocene). The reservoir is adjacent to Moss Agate Ridge, which is capped by the White River Formation (Oligocene). The exact type and origin of the agates that gave rise to these geographic names is unknown (Sutherland, 1990).

Solomon Springs area. Clear to blue-gray and black, lightly banded, botryoidal agate and moss agate are found in the Casper Formation (Alan Hinman, personal communication to Sutherland, 1988). The occurrence is in sections 35 and 36, T24N, R74W. Some pieces are stalactitic with concentric banding; other pieces consist of reddish-brown jasper (Sutherland, 1990).

Specimen Hill. A variety of agates have been found at Specimen Hill west of Little Medicine in section 19, T28N, R76W. The agates include plume, banded black, and dendritic agate, and jasper (Sutherland, 1990).

Shirley Basin petrified wood. T27N, R78W, and the surrounding areas of Shirley Basin have been known as sources of petrified wood since the 1930s. Humid subtropical woods such as palms and other species once grew here during the Eocene, as demonstrated by a forest of silicified logs and fallen trees with diameters up to 3 feet or more. The majority of this wood was hauled away by commercial collectors between the 1930s and 1950s (Sunderland, undated). The wood in the Wind River Formation ranged in color from white to brown to black, and is generally of poor quality. Typically, it breaks easily into small flakes (Sutherland, 1990). Harshman (1972) reported that the petrified forest area was located within sections 11, 12, 13, and 14, T27N, R78W.

Sierra Madre

There are two known occurrences of quartz crystals in this area. *Recommended map: U.S. Geological Survey topographic map of the Baggs 1:100,000-scale Quadrangle.*

Battle Lake. This occurrence is in section 2, T13N, R86W, and section 35, T14N, R86W. Southwest of Battle Lake in the general area of Battle Creek and Baby Lake Creek, quartz crystals have been found in cavities and fractures in red granite. The quartz occurs as terminations on the granite, and crystals are reported in a variety of colors, including amethyst, rose, smoky, milky-white, and clear. Most of the quartz crystals are small and less than 2 inches in length (Platt, 1947).

Gold Coin mine. Clear to milky quartz crystals up to 3/8 inch in length are found in a quartz vein near the Gold Coin mine in NE SW section 11, T15N, R87W (Sutherland, 1990). A milky quartz vein also contains galena, pyrite, chalcopyrite, and some gold and silver (Hausel, 1989).

Southeastern Wyoming

This part of Wyoming includes the Laramie Mountains, Laramie Basin, Goshen Hole, and the Saratoga Valley, and extends as far west as the Rawlins uplift. This area contains several types of chalcedony, including some petrified wood, as well as agates and jaspers derived from Paleozoic limestones, particularly from the Casper Formation (Pennsylvanian-Permian). The source of the silica that silicified some of the petrified wood was probably volcanic ash falls. The type of material found in this region is extremely varied in appearance, and includes several colors of jasper, jasp-agate, white moss agate, black agate or flint, and carnelian agate (Sutherland, 1990).

Big Creek copper mine. This mine is located in NW section 9, T13N, R81W. Some of the best copper specimens of massive chalcocite and bornite found in the state have come from this mine. The deposit occurs in a pink granite pegmatite (Houston, 1961). This pegmatite also contains common terminated quartz prisms. Much of the quartz is translucent, but specimens of excellent, transparent quartz similar to those found in Hot Springs County, Arkansas, are also found and relatively common (Ralph Platt, personal communication to Hausel, 1999). The Big Creek copper mine is erroneously listed as the Platt mine on the Trent Creek topographic map. *Recommended map: U.S. Geological Survey topographic map of the Trent Creek 1:24,000-scale Quadrangle.*

Farthing. In the Road Canyon area (section 28, T19N, R70W), about 4 miles north of Farthing and 1/2 mile east of the road, clear polka-dot agates, crinoid stems embedded in jasper, and jasper thunder eggs have been reported (Hayford, 1971). The source of the material is unknown. Limestone from the Madison Limestone/Casper Formation and the Goose Egg Formation occurs nearby, and may be a potential source. *Recommended map: U.S. Geological Survey topographic map of the Rock River 1:100,000-scale Quadrangle.*

Iron Mountain. Agates and jasper are found at Iron Mountain in sections 22, 23, 26, and 27, T19N, R71W (Anonymous, 1976). According to Ralph Platt (personal communication to Sutherland, 1988), the material is probably from a nearby limestone at Limestone Rim, which also contains some trilobites. The agates are similar in appearance to Dryhead agates (Sutherland, 1990). To the east in sections 7 and 18, T19N, R70W, cliff-forming limestones overlooking Hay Canyon contain common jasper and agates filling fractures in the limestones. *Recommended map: U.S. Geological Survey topographic map of the Rock River 1:100,000-scale Quadrangle.*

Red Mountain. Botryoidal agate and jasper were found around the base of Red Mountain in sections 16 and 21, T12N, R76W (Muriel Forney, personal communication to Sutherland, 1988). These are derived from outcrops of Casper Formation along the flank of the mountain (Sutherland, 1990). *Recommended map: U.S. Geological Survey topographic map of the Laramie 1:100,000-scale Quadrangle.*

Six Mile Hill-Sand Flats. Agatized wood and dendritic agates are found in sections 1, 2, 3, 10, 11, and 12, T18N, R84W, and sections 24, 25, 26, 27, 34, 35, and 36, T19N, R84W. These are the flats along State Highway 130 north of Saratoga. The host rock appears to be tuffaceous sandstones, siltstones, and claystones of the North Park Formation (Miocene) (Sutherland, 1990). *Recommended map: U.S. Geological Survey topographic map of the Rawlins 1:100,000-scale Quadrangle.*

According to the Cheyenne Gem and Mineral Society (1965), agates have been collected along Highway 130, 14 miles south of Walcott Junction. From Saratoga north to the Union Pacific Railroad main line, the flats contain common agatized and opalized woods which fluoresce green under ultraviolet light.

Slater. Johnson (1973) reported that dendritic agates from the hills near Slater (T22N, R66W) were probably derived from either the White River Formation (Oligocene) or the Arikaree Formation (Miocene/upper Oligocene).

Both formations contain tuffaceous material, which may indicate a volcanic silica source for these agates. *Recommended map: U.S. Geological Survey topographic map of the Chugwater 1:100,000-scale Quadrangle.*

Table Mountain. Carnelian agate is reported in sections 25, 26, 35, and 36, T15N, R70W, near Table Mountain in the Silver Crown district (Aughey, 1886; Osterwald and others, 1966). *Recommended map: U.S. Geological Survey topographic map of the Laramie 1:100,000-scale Quadrangle.*

Wheatland Reservoir. Jasper and agate are found associated with the Casper Formation north of Wheatland Reservoir #2 in NE section 3, T22N, R73W (W. Dan Hausel, personal field notes, 1983). *Recommended map: U.S. Geological Survey topographic map of the Rock River 1:100,000-scale Quadrangle.*

Washakie Basin

The Washakie Basin is a subbasin in the eastern Greater Green River Basin. It is separated from the Great Divide Basin to the north by the east-trending structure called Wamsutter arch. The axis of this arch approximately follows the route of Interstate 80 between Rawlins and Point of Rocks. *Recommended maps: U.S. Geological Survey topographic maps of the Rawlins, Red Desert Basin, and Kinney Rim 1:100,000-scale quadrangles.*

Coal Gulch-Eight Mile Lake. Petrified wood in a variety of colors has been found in Ts17 and 18N, R93W, along the road between Wamsutter and Baggs near the Continental Divide (Cheyenne Gem and Mineral Society, 1965; Johnson, 1973).

Delany Rim. An agate erroneously termed "*Turritella* agate" is found in the area of T18N, R96W; the agate actually is formed of silicified *Goniobasis* fossil snails (Hausel, 1986b). The rock is dominantly brown to gray and is part of a silicified layer in the Laney Member of the Green River Formation. The *Goniobasis* are distinguished from *Turritella* gastropods by their freshwater habitat as well as their shorter (usually less than 1 inch) length and fatter appearance than the marine *Turritella* gastropods (Breithaupt, 1983).

The western part of this township is a good collecting area for the gastropods and other agates (Eloxite Corporation, 1971; Johnson, 1973). Three separate limestone units on Delany Rim are locally replaced by silica. The uppermost unit consists of *Goniobasis* chert, the middle unit consists of silicified algal heads, and the lower unit consists of oolitic limestone (Hausel and others, 1994).

Haystack Hills. The Haystack Hills (Ts16 and 17N, Rs95 through 97W) are a source for several types of agate including petrified wood, oolitic agate, and petrified algae (Ralph Platt, personal communication to Sutherland, 1988). These agates appear to be associated with the Washakie Formation (Eocene). In this same region, areas underlain by the Laney Shale Member of the Green River Formation (Eocene) are a source for *Goniobasis* agate.

Ketchem Buttes. Ketchem Buttes, in T15N, R89W, is located 25 miles south of Rawlins. They were explored in the 1950s for uranophane in the lower part of the North Park Formation (Miocene). Ketchem Buttes and the surrounding buttes were interpreted as remnants of paleo hot springs, as they are capped by travertine (Gordon Marlatt, personal communication to Hausel, 1993a). The easternmost butte contains silica bands in the form of red jasperoid that partially replaces sandstone and limestone (Hausel and others, 1994).

Miller Hill. Lovering (1972) reported jasperoid in the Miller Hill area (T18N, Rs88 and 89W) about 25 miles south of Rawlins. The jasperoid was reported to be associated with localized concentrations of uranium ore. In this area, thin (3- to 10-foot-thick) fresh-water limestone beds within the Browns Park Formation (Miocene) have been locally brecciated and replaced by silica. The silica was apparently leached from porous tuffaceous sandstones and precipitated in the limestone by groundwater.

Savery Creek prospect. This occurrence is in section 32, T16N, R88W, and section 6, T15N, R88W. Five miles east of Ketchem Buttes in the Savery Creek area, some limestone has been completely silicified (Hausel and others, 1994).

Wind River Basin

Several agates are found in the Wind River Basin. Attractive rainbow agates are reported along the Wind River near Riverton and several varieties of agate are found in the Lysite area.

Crowheart Butte. Located east of Crowheart in T4N, R3W, Wind River Meridian. Good quality petrified oak is found near Crowheart Butte (Ralph Platt, personal communication to Sutherland, 1990). *Recommended map:*

U.S. Geological Survey topographic map of the Gannett Peak 1:100,000-scale Quadrangle.

Fossil Hill. Clear to gray botryoidal to stalactitic agate was found in the Bighorn Dolomite (Ordovician), and as loose debris on slopes of Fossil Hill in section 25, T32N, R101W (Gary B. Glass, personal communication to Sutherland, 1990). *Recommended map: U.S. Geological Survey topographic map of the Lander 1:100,000-scale Quadrangle.*

Lysite. An area immediately south of Lysite in sections 30 and 31, T38N, R90W, and sections 35 and 36, T38N, R91W, contains several varieties of agate including *Goniobasis* agate and petrified wood. The material occurs as float, some of which has been wind polished (Rohn, 1986). *Recommended map: U.S. Geological Survey topographic map of the Lysite 1:100,000-scale Quadrangle.*

Lysite Mountain. Agate is reported from Lysite Mountain (T40N, R90W) (Johnson, 1973). The material is probably derived from Paleozoic limestones. *Recommended map: U.S. Geological Survey topographic map of the Lysite 1:100,000-scale Quadrangle.*

Wind River Range

There are a number of quartz, chalcedony, and agate occurrences in and near the Wind River Range. *Recommended map: U.S. Geological Survey topographic map of the Lander 1:100,000-scale Quadrangle.*

Beaver Creek. Jasperized and isoclinally folded banded iron formation occur on a knob north of Beaver Creek and north of the Atlantic City iron mine site in T30N, R100W (W. Dan Hausel, personal field notes, 1998).

Cherry Creek. Agates associated with Jurassic rocks are found in section 25, T31N, R99W, near State Highway 28 south of Lander. The area is on the flank of Wind River uplift (Harris and others, 1985).

Dry Lake area. Yellow to tawny moss jasper, known as Yellow Tree agate, is reported west of State Highway 28 at the base of Limestone Mountain (approximately located in sections 7, 8, and 9, T30N, R99W). The agates have black tree-like dendritic patterns. Samples of this material have produced some very attractive cabochons (Spendlove, 1984). These are partially carbonatized with an oxidized outer coating or surface (Sutherland, 1990).

Sand Creek. Chrysoprase has been reported along the south side of Sand Creek. Sand Creek is a tributary of Beaver Creek and is located south of Lander in Fremont County (Cheyenne Gem and Mineral Society, 1965). No specific location was given.

South Pass. Clear to milky and ferruginous quartz crystals have been found in some veins in the South Pass mining district along the southern tip of the Wind River Range (T29N, R100W) (Sutherland, 1990). These crystals, however, are uncommon.

Twin Creek. Irregularly banded, red and golden-yellow *flame* jasper, is found associated with the Amsden (Mississippian/Pennsylvanian) or Phosphoria Formation (Permian) in the Twin Creek area north of South Pass in SW section 14, T30N, R99W. The jasper takes a high polish and yields very attractive specimens (**Figure 93, Plate 11**) (Hank Hudspeth, Jr., personal communication to Sutherland, 1990).

Yellowstone National Park

Amethyst Mountain. Amethyst and rock crystals fill voids in some petrified wood and wood casts in the vicinity of Amethyst Mountain (T56N, R111W) in Yellowstone National Park. These crystals are found over a wide area (Sinkankas, 1959).

RARE EARTH MINERALS

There are numerous rare earth minerals and most are very difficult to identify. Their positive identification often requires X-ray diffraction (XRD) methods. Most rare earth minerals are slightly radioactive, and are complex both chemically and physically. For a detailed summary of rare earth minerals found in Wyoming, the reader should review a paper by King and Hausel (1991). Two areas in Wyoming are particularly known for rare earth minerals: the Bear Lodge Mountains in northeastern Wyoming and the Big Creek district in southeastern Wyoming. Most rare earth minerals in the Bear Lodge Mountains are fine-grained and difficult to identify. Only the

Big Creek district is discussed below as it has yielded some good specimens in past years.

Big Creek district. Located in T13N, R81W, several rare earth minerals have been found here. Houston (1961) recognized a group of complex pegmatites in the district with cross-cutting relationships to country rock foliation. These were poorly zoned with a quartz-rich core and a graphic granite outer border. Mineralogically, the pegmatites contained feldspar and quartz with accessory garnet, tourmaline, biotite, muscovite, fluorite, rare monazite [$(Ce,La,Y,Th)PO_4$], allanite [$(Ca,Fe)_2(R,Al,Fe)_3Si_3O_{12}OH$], euxenite [$(Y,Er,Ce,La,U)(Nb,Ti,Ta)_2(O,OH)_6$], and columbite [$(Fe,Mn)(Nb,Ta)_2O_6$] (see also **BERYL**). The R in the allanite formula represents the metal ions Ce, Di, or La.

The euxenite pegmatite at the Platt mine east of the Big Creek copper mine in SW section 3, T13N, R81W, produced some of the best prismatic, orthorhombic, euxenite specimens in the world. According to Ralph Platt (personal communication to Hausel, 1999), this pegmatite was at one time the best source of euxenite in the world. The euxenite is black, vitreous, opaque, and weakly radioactive. *Recommended map: U.S. Geological Survey topographic map of the Elkhorn Point 1:24,000-scale Quadrangle.*

RARE AND UNUSUAL ROCKS

Wyoming is covered with rocks! Few places in the world have better exposures of rocks. While exploring the outback of Australia for diamonds, the wilderness of Alaska for gold, and much of the conterminous United States for diamonds and gold, the senior author has noticed the lack of rock exposures in these regions compared to Wyoming. The only place the senior author visited with comparable rock exposures was the glacier-swept region around Yellowknife in the Northwest Territories of Canada. Although the Yellowknife area has some beautiful rock exposures, they are not as accessible as those in Wyoming, nor are they quite as varied as the Cowboy State.

Some rocks in Wyoming are attractive because of their appearance, and others are attractive because of their uniqueness. For example, rocks known as lamproites found in the Leucite Hills north of Rock Springs are quite rare, and may represent some of the rarest rocks on Earth's surface. However, these rocks are not attractive to most lay persons, having the appearance of common volcanic rocks. Lamproites include four different types or varieties, including wyomingite, which until fairly recently, was only known to occur in Wyoming. Only a few other lamproite localities are known in the world.

Other rocks found in Wyoming are also unique. Some are considered as lapidary materials by virtue of their intrinsic beauty. Some have been used in ornamental objects including terrazzo, book ends, paper weights, etc.

Folded rocks

Some spectacular folded metamorphic rocks are found in many of Wyoming's mountain ranges or uplifts. These include isoclinally folded iron formation, pelitic schists, and related rocks. Some of the better examples of folded rocks have been found in the South Pass area of the Wind River Range, the Seminoe Mountains, and the Snowy Range in the Medicine Bow Mountains. The latter two occurrences are discussed below.

Seminoe Mountains. Spectacular folded banded iron formation occurs in the Seminoe Mountains region in section 20, T26N, R85W, north of Sinclair (**Figure 92, Plate 11**) (Hausel, 1994b). Strongly isoclinally folded, tawny to gray banded iron formation consisting of quartz-magnetite-grunerite in the Seminoe Formation occurs in the vicinity of Junk Creek (Blackstone and Hausel, 1992).

Snowy Range. Folded graphitic slate and phyllite of the Precambrian (Archean) French Slate is exposed in section 14, T16N, R79W, along the north side of the Snowy Range Scenic Highway near the Nash Fork campground. The rock contains some spectacular complexly folded and crenulated beds (Hausel, 1993a).

Kimberlite

Kimberlite is a rare ultrabasic, potassic, hybrid igneous rock that sometimes contains diamonds as well as other potential gemstones (**Figure 27, Plate 3**). The rock is composed primarily of serpentine and will produce an attractive rock when cut and polished. Some kimberlite from the Sloan 1 intrusive in Colorado (within the Colorado-Wyoming State Line district) was once cut and polished for use as terrazzo in some buildings in the Wyoming and Colorado area until diamonds in the rock matrix scratched the polishing wheels (Frank Yaussi, personal communication, 1985).

Kimberlite localities are described under **DIAMOND**. Some of the better kimberlite rock samples have been found at the Sloan 1, Nix 1, Iron Mountain, Ferris 2, and Radichal intrusives. These rocks consist of greenish to black kimberlite porphyry with olivine megacrysts. Some of the better samples contain pyrope, chrome diopside, and picroilmenite megacrysts in a fine-grained serpentine matrix. Although uncommon, some museum-quality specimens have been found with eclogite and/or peridotite xenoliths.

Komatiite

Komatiite is a rare rock in the United States and has an unusual appearance. This relatively rare volcanic rock is almost exclusively confined to ancient Archean greenstone terranes, although some Proterozoic komatiites have been reported in other parts of the world. These rocks represent primitive mafic to ultramafic volcanic flows that erupted on ancient sea floors more than 2.5 billion years ago. Typically, the rocks consist of radiating to parallel crystals of hornblende in a fine-grained chloritic groundmass. Metamorphosed komatiites and komatiitic rocks have been reported in several greenstone terranes in Wyoming. For the most part, these have been intensely deformed and can now only be recognized by their geochemical signatures, geological setting, and mineralogy. However, a few komatiites are well-preserved, particularly in the Seminoe Mountains greenstone belt (**Figure 49**). Where preserved, these rocks consist of a fine-grained matrix of actinolite or serpentine with crystals of radiating hornblende forming a *turkey track* texture (**Figure 94, Plate 11**). Both spinifex- and cumulate-textured metakomatiites are found in the Seminoe Mountains greenstone belt. These were first identified by Klein (1982).

The *spinifex* texture produced by the radiating hornblende has a similar appearance to a spiney spinifex grass found near the Komati River in southern Africa where these rare rock types were initially recognized (Hausel, 1994b). The komatiite flows typically consist of a top layer with spinifex-textured top produced by rapid crystallization and cooling of the flow (caused by contact with sea water) whereas the base of the flows cool slowly and were formed by crystallization and settling of olivine in the magma, which produces the *cumulate*-textured, equigranular olivine-rich rock. *Recommended map: Geologic map of the Seminoe Mountains greenstone terrane, in Hausel (1994b, map in pocket). This map shows the specific locations of the komatiitic units.*

Bradley Peak. Spinifex- and cumulate-textured basaltic metakomatiites are found in W/2 section 5, T25N, R85W, and section 31, T26N, R85W. They occur in the Bradley Peak ultramafics along the eastern flank of Bradley Peak near the western edge of the Precambrian core of the Seminoe Mountains.

Sunday Morning Creek. Ultramafic (peridotitic) metakomatiites are found along Sunday Morning Creek (section 21, T26N, R85W) on the north flank of the Seminoe Mountains greenstone belt. These consist of tremolite-talc-chlorite-serpentine schist with radiating crystals of tremolite and serpentine. Many of these spinifex units are underlain by a granular appearing serpentinite schist consisting of cumulate-textured komatiite which forms the base of the ultramafic volcanic flows (Hausel, 1994b). The original olivine in these cumulate flows has been replaced by serpentinite.

Lamproite (also see PERIDOT)

The Leucite Hills volcanic field in southwestern Wyoming consists of a group of extremely rare volcanic rocks known as lamproites. These could be the rarest rock type on earth. Lamproites are ultrapotassic mafic igneous rocks that sometimes contain diamonds (Hausel, Sutherland, and Gregory, 1995). A few of these have been mined on a small scale for decorative rock, and placed in gardens surrounding private homes. The rocks have also been studied as a potential source of potassium. For information on accessibility, land ownership, and collecting in the Leucite Hills, see the discussion under **PERIDOT**.

The Leucite Hills consists of 22 known (3.1 to 1.1 Ma) lamproite flows, dikes, necks, plugs, cinder cones, and pumice cones lying along the northern flank of the Late Cretaceous-Paleocene Rock Springs uplift (**Figure 77**) (Hausel, Sutherland, and Gregory, 1995; Hausel, Love, and Sutherland, 1995; Bradley, 1964; McDowell, 1966, 1971). Both olivine and leucite lamproites are present. Geochemically, these have SiO_2 contents in the range of 42.65 to 56.34%; K_2O contents from 2.52 to 12.66%; and MgO contents from 5.8 to 12.75%.

The volcanic centers consist of vesicular lavas, scoria, autolithic intrusive breccias, lapilli tuffs, tuff breccias, and agglomerates of diopside-leucite-phlogopite-lamproite, diopside-sanidine-phlogopite-lamproite, and diopside-madupitic lamproite. Vents are associated with most of the igneous bodies, although vents are not conspicuous at South Table Mountain, North Table Mountain, Black Rock, or Hatcher Mesa (Ogden, 1979).

The Leucite Hills lamproites contain a variety of xenoliths such as arkose, tuffaceous sandstone, argillite, siltstone, gabbro, anorthosite, and an assortment of granitic rocks. Some cognate xenoliths include lamproitic fragments of coarse-grained intergrowths of phlogopite-diopside-apatite-priderite-magnophorite with an ocelli texture. Barton and van Bergen (1981) also reported phlogopite-chromite-harzburgite, orthopyroxene amphibolite, clinopyroxene-rich pyroxenites, and mica-rich xenoliths.

Xenocrysts found in some of the lamproites include augite, barkvikitic amphibole, and orthoclase. Cognate xenocrysts include olivine with reaction rims of phlogopite, chromites with similar reaction rims, and green spinels (Carmichael, 1967).

Cross (1897) introduced three new names for these unusual rocks. A fourth type was later proposed by Carmichael (1967) for the olivine-bearing flows at South Table Mountain and North Table Mountain (olivine also occurs in the lamproites at Wortman dike, Endlich Hill, and Black Rock). The four rock types include: (1) *madupite*, a diopside-rich glassy volcanic rock with poikilitic phlogopite phenocrysts enclosing diopside set in a groundmass of leucite, diopside, apatite, and glass; (2) *wyomingite*, an ultrapotassic volcanic rock with microphenocrysts of phlogopite and diopside in a groundmass of leucite, diopside, apatite, and glass; (3) *orendite*; and (4) *olivine orendite*. These latter two rock types are petrographically identical, having microphenocrysts of phlogopite and diopside in a groundmass of olivine, leucite, apatite, and richterite, with considerable sanidine. Petrographically, the presence of sanidine distinguishes orendite from wyomingite.

Carmichael (1967) reported that the Wyoming madupites are distinct with no counterpart in Western Australia (another significant area with lamproites), and Kuehner (1980) reported that the Leucite Hills contain the only known madupites in the world. According to Carmichael (1967),

> *The diagnostic texture of the madupites of phlogopite enclosing diopside, together with small crystals of magnetite and perovskite is identical to that found in the Arkansas kimberlite; olivine or its pseudomorph has never been found in a madupite, however.*

[Author's note: the Arkansas kimberlite described by Carmichael is now known to be a diamondiferous olivine lamproite.]

Leopard rock and orbicular granodiorite

Leopard rock refers to distinctly spotted rocks that have a dark matrix enclosing relatively large, rounded, white feldspar or quartz grains (**Figure 95, Plate 12**). This rock is somewhat unique and is sought by some collectors for use as paperweights, bookends, and for other decorative rocks. Orbicular granodiorite is also an unusual rock containing rounded orbs in a granodiorite matrix (**Figure 96, Plate 12**). Both rock types have been found in Wyoming at the localities described below.

Burgess Junction. Leopard rock is found near Burgess Junction (T56N, R88W) in the Bighorn Mountains. It consists of a dark mafic rock which intrudes Precambrian quartz monzonite (Manzer and Heimlich, 1974). Additionally, some porphyritic gabbroic dikes in the area contain abundant phenocrysts of altered plagioclase feldspar that are 2 to 3 inches across. These produce a distinct white spotted appearance (Sutherland, 1990).

Recommended map: U.S. Geological Survey topographic map of the Burgess Junction 1:100,000-scale Quadrangle.

Ferris Mountains. Master (1977) reported orbicular granodiorite in C N/2 SW section 30, T27N, R87W, near Young's Pass in the Ferris Mountains. The rock has dark-gray quartz diorite orbicules enclosed by lighter gray granodiorite groundmass (**Figure 96, Plate 12**). *Recommended map: U.S. Geological Survey topographic map of the Baroil 1:100,000-scale Quadrangle.*

Lewiston area. A spotted metabasalt (**Figure 95, Plate 12**) was discovered by the senior author in a rock unit called Roundtop Mountain Greenstone in the Lewiston district along the eastern flank of the South Pass greenstone belt. The basalt occurs south of the Sweetwater River in the vicinity of Granite Creek (section 15, T28N, R98W) near the Antelope Hills. The rock consists of 0.25- to 0.5-inch-diameter white xenocrysts of clinozoisite after plagioclase feldspar in a black, aphanitic groundmass (Hausel, 1991a). *Recommended maps: 1:50,000-scale geologic map of the South Pass greenstone belt in Hausel, 1991a; and 1:24,000-scale geologic map of the Lewiston district, Hausel, 1986d).*

Seminoe Mountains. A plug containing spectacular specimens of leopard rock was recently discovered in SE section 20, T26N, R85W, along the northwestern flank of the Seminoe Mountains (**Figure 95, Plate 12**). The rock is a metagabbro formed of black amphibole-rich groundmass surrounding 0.25- to 1.0-inch-diameter rounded white feldspar xenocrysts encased in white reaction rims (Hausel, 1994b). *Recommended map: 1:24,000-scale geologic map of the Seminoe Mountains in Hausel (1994b).*

Peanut schist

Peanut schist is a term applied to a few porphyroblastic pelitic schists with nodular grains of andalusite or cordierite that are found in some of Wyoming's metamorphic terranes. In particular, peanut schist occurs within the South Pass greenstone belt (see **ANDALUSITE, KYANITE, SILLIMANITE, STAUROLITE**) in the vicinity of the Rose mine (**Figure 94, Plate 11**). Throughout Wyoming's mountain ranges, mica-rich porphyroblastic schists are common and include a variety of porphyroblasts including kyanite, sillimanite, cordierite, andalusite, staurolite, and corundum (**Figure 97, Plate 12**).

Serpentinite

Wyoming has several attractive serpentinites (**Figure 98, Plate 12**). Many of these are closely associated with greenstone belts and related Archean supracrustal belt fragments. These are often very deep green to yellow-green and have been mistaken for apple-green jade. However, serpentinite is softer (it can be scratched with a knife) and is always weakly magnetic (unlike jade) due to the serpentinization process.

Tin Cup district. Excellent samples of serpentinite are found in SW section 13, T30N, R93W, in the Tin Cup district of the Granite Mountains. Locally, this serpentinite contains light-blue sapphire (W.D. Hausel, personal field notes, 1995). *Recommended map: U.S. Geological Survey topographic map of the Rattlesnake Hills 1:100,000-scale Quadrangle.*

Spotted ultramafic schist

Tin Cup district. An ultramafic schist with an unusual, distinct spotted texture lies northeast of the Sutherland mine in the Tin Cup district of the Granite Mountains. Located in SE SE section 25, T31N, R93W, the spotted ultramafic schist is a green chlorite-actinolite schist with large rounded (1-inch-diameter), magnetite clots surrounded by small, light-tan reaction rims (W.D. Hausel, personal field notes, 1995). *Recommended map: U.S. Geological Survey topographic map of the Rattlesnake Hills 1:100,000-scale Quadrangle.*

RUBY (see CORUNDUM)

SAPPHIRE (see CORUNDUM)

SELENITE

Selenite ($CaSO_4 \cdot 2H_2O$), a crystalline form of gypsum, is found in a number of Tertiary and Cretaceous shales in Wyoming. Where found, the selenite crystals are transparent to opaque, colorless to white, vitreous, and prismatic to tabular. Sometimes selenite forms "fishtail" twinned crystals.

Selenite has a low specific gravity of only 2.32, and a very low hardness of only 2. The surface of the crystal can therefore be scratched with a fingernail and thus, due to its softness, selenite cannot be used as a gemstone. However, a variety of gypsum known as satin spar is a white, silky to pearly, striated form of selenite, with numerous striations parallel to $m\{001\}$. These have cleavage in three directions - one $m\{010\}$ that is well developed. Some satin spar specimens collected in Wyoming are very attractive, and specimens more than a foot in length have been found in the state.

Shaley units with scattered selenite crystals often produce a sparkling appearance when sunlight reflects off the crystal faces. Selenite crystals range from small grains to some unusually long crystals up to a foot in length. Some formations that commonly contain selenite include the Thermopolis (Lower Cretaceous), Cody, Niobrara, and Steele shales (Upper Cretaceous), as well as carbonaceous shales within the Fort Union (Paleocene) and Wasatch formations (Eocene).

Midwest. A selenite occurrence is reported in the Powder River Basin near the town of Midwest in section 20, T40N, R79W. Selenite crystals up to 3 inches in length are found in bentonite of the Steele Shale (Osterwald and others, 1966).

Natrona. In the Wind River Basin, near the town of Natrona, selenite crystals found in the Steele Shale are especially abundant in the northern half of sections 3 and 4, T36N, R83W (Osterwald and others, 1966).

SILVER

Silver is an important precious metal that has been overlooked in Wyoming because it lacks significant historical production. Silver had been produced in Wyoming as a by-product of gold and copper mining and based on available (but incomplete) production records, at least 157,000 ounces of silver were recovered from Wyoming mines in the past (Hausel, 1997a). The principal silver districts are in the Absaroka Mountains of northwestern Wyoming, where large copper-silver porphyries are surrounded by radiating quartz veins. The two best known silver districts in Wyoming are the Sunlight district west of Cody and the Kirwin district west of Meeteetse.

According to Parkhurst (1991) there are at least 55 known silver minerals. In Wyoming, only a few argentiferous minerals have been identified: native silver (Ag), argentiferous galena (PbS), tetrahedrite [(Cu, Fe, Zn,

$Ag)_{12}(Sb, As)_4S_{13}]$, stephanite ($Ag_5SbS_4$), sylvanite [$(Au,Ag)Te_2$], proustite ($Ag_3AsS_3$), stromeyerite ($AgCuS$), and cerargyrite ($AgCl$). Silver is often found associated with lead, copper, and gold; silver is malleable, ductile, and has a high specific gravity ranging from 10 to 11.

Some of the more significant silver deposits in Wyoming are found in the Kirwin district southwest of Meeteetse (see **ORE MINERALS**). Some mines in this district reportedly contained ore-grade and specimen-grade silver. These included the Oregon, Little Johnnie, and Bryan mines and the Galena Ridge tunnel. The vein at the Oregon mine, for example, reportedly yielded an average of 17.8 opt Ag with 0.08 opt Au across 3-foot vein widths. The vein at Little Johnnie yielded samples that assayed 64.7 opt Ag and 0.12 opt Au across widths of 1.5 feet. One select sample from the mine dump assayed 156 opt Ag! According to Rostad (1982), some of the best silver values were obtained at or next to the mine faces (at the end of the tunnels), where exploration and production work had ended.

At the Bryan mine on nearby Spar Mountain, 31 samples taken over a strike length of 98 feet averaged 0.13 opt Au, 29.5 opt Ag, and 0.73% Cu (Rostad, 1982). Some extremely rich samples were collected from the nearby Mendota vein in the Galena Ridge tunnel. A select sample collected across a half-foot of this vein averaged 101.35 opt Ag and 0.283 opt Au.

SPODUMENE

Spodumene [$LiAl(Si_2O_6)$], a lithium-bearing clinopyroxene, is uncommon in Wyoming, but where found, the mineral occurs in pegmatites. Spodumene occurs as monoclinic prisms with rectangular cross-sections and striations along the $m\{100\}$ pinacoid. In addition, the mineral has cleavage parallel to the $m\{110\}$ face.

Gem-variety spodumene occurs elsewhere in the world as transparent pink, violet, and purple varieties known as kunzite; colorless to yellow gems known as triphane; and emerald green varieties known as hiddenite. Spodumene has a hardness that ranges from 6.5 to 7.5, and a specific gravity of 3.17 to 3.23.

Spodumene as found in granitic pegmatites typically occurs as opaque, white, or pink crystals in flattened or striated *Roman sword* euhedral crystals. The largest known spodumene crystal was apparently found at the Etta Mine in the Black Hills of South Dakota. That crystal measured 42 feet in length, and was estimated to weigh 90 tons. Gem spodumene has been mined from the Pala district of San Diego County, California, and from the Minas Gerais area, Brazil.

Granite Mountains

Black Mountain pegmatite. Located west of the Rattlesnake Hills (SE section 36, T33N, R89W) in the northern Granite Mountains of central Wyoming, this is the only known spodumene pegmatite in Wyoming. The spodumene occurs in crystals as large as 2 feet in length and 6 inches in diameter.

The pegmatite trends N75°E, is about 200 feet long, and is from 1 to 10 feet wide. The spodumene found in the pegmatite is described to be blue-gray, greenish, and pale lavender. The spodumene occurs in a milky quartz matrix with plagioclase and cleavelandite and is found associated with black and green tourmaline, and greenish-blue fluorapatite. Locally, the spodumene forms about 10% of the pegmatite (Jacobson, 1997). Some small bluish minerals collected from the matrix of the pegmatite by the Wyoming State Geological Survey yielded an XRD pattern which matched fluorapatite (Robert W. Gregory, personal communication, 1996). *Recommended maps: U.S. Geological Survey topographic maps of the Ervay Basin SW 1:24,000-scale Quadrangle and Rattlesnake Hills 1:100,000-scale Quadrangle.*

Wind River Range

Anderson Ridge. Some spodumene is reported in association with tourmaline at Anderson Ridge (NE section 24, T29N, R101W) in the Wind River Range (see **TOURMALINE**).

TOPAZ

Topaz [$Al_2(SiO_4)(F, OH)_2$] is well-known as a light-yellow gemstone, although the mineral occurs in other colors including light-green, brown, and colorless. Topaz has a relatively high hardness (8), a specific gravity of 3.4 to 3.6, and is orthorhombic in crystal form, usually with a combination of prisms forming elongated 8-sided columns terminated by a pyramid. Striations parallel to the c-axis [*m*{001}] are common, and a perfect basal cleavage forms perpendicular to the c-axis (Bauer, 1968a).

Topaz is pyroelectric (it acquires an electric charge when heated), and like amber, will also acquire an electric charge, when stimulated by rubbing. Topaz has a vitreous luster.

Topaz precipitates from fluorine-bearing vapors during late-stage crystallization of igneous rocks, and is generally found in cavities in rare rhyolites and granites, and in some pegmatites, particularly those that are tin-bearing (Hurlbut, 1966). Topaz has been reported in the Mineral Hill district (T51N, R60W) of the Black Hills, Wyoming and South Dakota. Irving and Emmons (1904) described minute grains of topaz with cassiterite in some placers surrounding Mineral Hill near Tinton. *Recommended map: U.S. Geological Survey topographic map of the Sundance 1:100,000-scale Quadrangle.*

Other prismatic topaz, similar to the well-known topaz from the Thomas Range in Utah, was reportedly found in the headwaters of the Bighorn River in northern Wyoming. The largest specimen measured 13 by 10 by 5 millimeters (U.S. Geological Survey, 1914). The source of the topaz is unknown.

TOURMALINE

Tourmaline [$Na(Mg,Fe)_3Al_6(OH)_4(BO_3)_3(Si_6O_{18})$] is a complex aluminum silicate with boron, sodium, magnesium, and iron. Large amounts of iron in the crystal lattice produce an opaque black tourmaline known as schorl, which renders the crystal unsuitable as a gemstone (**Figure 99, Plate 12**) (Bauer, 1968a). Occasionally, some crystals of tourmaline are found that are relatively free of fractures and other flaws, and are translucent to transparent pale pink, red, violet, yellow, brown, light-green, or light-blue; these may produce a potentially attractive gemstone.

Tourmaline belongs to the hexagonal crystal system, and typically forms prismatic crystals with rounded triangular cross sections. Striations are common parallel to the c-axis (long axis), and basal fractures are perpendicular to the striations. Tourmaline exhibits a hardness of 7 to 7.5 and specific gravity of 3.03 to 3.25.

Granite Mountains

Black Mountain pegmatite. Located in SE section 36, T33N, R89W, of the western Granite Mountains, this pegmatite consists of quartz and feldspar with cleavelandite associated with black and bluish-green opaque tourmaline and some spodumene and apatite (Hanley and others, 1950) (see also **SPODUMENE**). *Recommended map: U.S. Geological Survey topographic map of the Rattlesnake Hills 1:100,000-scale Quadrangle.*

Hartville uplift

There are five occurrences of tourmaline reported in this uplift. *Recommended map: U.S. Geological Survey topographic map of the Torrington 1:100,000-scale Quadrangle.*

Chicago prospect. Black tourmaline occurs in the border zone of the poorly zoned Chicago pegmatite at Garnet Hill in SW NE and SE NW section 35, T28N, R65W. Similar schorl is found in the Ruth pegmatite about 600 feet to the south (Hanley and others, 1950).

Crystal Palace pegmatite. The Crystal Palace pegmatite on Garnet Hill in NE section 34 and NW section 35, T28N, R65W, consists of an indistinctly zoned pegmatite, 10 feet wide and 70 feet long, that cuts the Precambrian Whalen schists and gneisses. The pegmatite contains a wall zone with accessory black tourmaline rich in muscovite. Schorl occurs in much greater concentrations at the contact of the pegmatite with the wall rock (Hanley and others, 1950).

Haystack No. 1 prospect. Schorl tourmaline is abundant in a pegmatite at this prospect in section 1, T27N, R65W (Hanley and others, 1950).

New York pegmatite. The New York pegmatite in NE NW and NW NE section 35, T28N, R65W, is 35 feet wide at maximum width, and well zoned. It contains an outer 1- to 2-foot-wide mica-bearing zone with common schorl. Some crystals are reported to be 8 inches in diameter (Hanley and others, 1950).

Torrington No. 1 prospect. Black tourmaline occurs throughout this pegmatite which is located 1450 feet east-northeast of the Crystal Palace pegmatite in section 35, T28N, R65W (Hanley and others, 1950).

Laramie Mountains

There are two reported occurrences of tourmaline in this mountain range. *Recommended map: U.S. Geological Survey topographic map of the Laramie Peak 1:100,000-scale Quadrangle.*

Casper Mountain. Schorl was reported in pegmatites in the core of Casper Mountain in sections 16, 17, 18, 19, and 20, T32N, R79W (Beckwith, 1939).

Palmer Canyon. This occurrence is in section 11, T24N, R71W. Deep pink, translucent tourmaline crystals less than 1 mm in size were recovered from stream sediment sample concentrates collected in Lumen Creek upstream from the Palmer Canyon cordierite deposit (see **CORDIERITE**). Sampling procedures (for recovering kimberlitic indicator minerals) limited the material size to less than 2 mm (Hausel and others, 1988), so larger pink tourmaline crystals may occur in nearby host rocks.

Medicine Bow Mountains and Sierra Madre

There are a number of tourmaline occurrences in this area. *Recommended map: U.S. Geological Survey topographic map of the Saratoga 1:100,000-scale Quadrangle.*

Big Chief. Light-green tourmaline(?) is reported in the Big Chief pegmatite (section 20, T14N, R83W) in the southern Medicine Bow Mountains. Some muscovite and kyanite are also reported in the pegmatite (Osterwald and others, 1966).

Big Creek district. Granite pegmatites are found throughout the Big Creek district in T13N, Rs80 and 81W. Houston (1961) recognized two types of pegmatites in the district: a simple pegmatite that is conformable to regional foliation in the host amphibolite gneiss and schist, and a pegmatite that cross-cuts foliation and has poorly developed zoning. In addition to quartz and feldspar, these pegmatites may contain garnet, tourmaline, biotite, muscovite, fluorite, and rarely monazite, allanite, euxenite, and columbite (see **BERYL**).

Cumberland Gulch. Tourmaline is found in tourmaline-garnet-mica schists in sections 26, 34, and 35, T18N, R82W. For more details, see this occurrence in **GARNET**, under the Medicine Bow Mountains subheading.

Muscovite and Ione claims. These claims are in section 32, T13N, R78W. Beckwith (1937) reported schorl crystals up to several inches in length in these pegmatites, as well as in the adjacent metadiabase, hornblende schist, and gneiss wall rock (see also **BERYL**).

Woods Landing bridge. Large black tourmaline crystals are reported in pegmatites immediately south of the Woods Landing bridge over the Laramie River near Jelm, Wyoming (Cheyenne Gem and Mineral Society, 1965).

Wind River Range

There are two occurrences of tourmaline reported for the Wind River Range. *Recommended map: U.S. Geological Survey topographic map of the South Pass 1:100,000-scale Quadrangle.*

Anderson Ridge. Several pegmatites cut granite in the Anderson Ridge area (Ts28 and 29N, Rs101 and 102W) along the southern margin of the South Pass greenstone belt. Tourmaline pegmatites are present in the central part of the Anderson Ridge Quadrangle (Hausel, 1986a) and extend to the northeast. Tourmaline-bearing pegmatite is also present in the southern part of sections 23 and 24, T29N, R102W. The individual crystals are schorl, and vary from millimeter size to more than 8 inches in length and 2 inches in diameter. Most of the crystals are euhedral to subhedral with excellent triangular cross-sections (**Figure 99, Plate 12**), but are fractured (El-Etr, 1963).

Section 24, T29N, R102W. Pegmatitic granite and pegmatites cut metagraywacke of the Miners Delight Formation. The pegmatites contain schorl (Hausel, 1986a). One pegmatite in this area is reported to contain a thin central core with blue tourmaline, some spodumene, and lepidolite (Bayley, 1965).

ZIRCON

Zircon [Zr(SiO4)] can produce semi-precious stones when transparent, free of flaws, and large enough to be cut. Zircon has a specific gravity of 4.68, a hardness of 7.5, and typically forms district tetragonal crystals with a rectangular prism terminated by dipyramids. Most often, zircon is opaque and yellowish brown, although it may be brown, red, yellow, or colorless. Gem-quality zircon is termed hyacinth (Bauer, 1968b).

The luster of zircon is adamantine, and in combination with its high refractive index (1.92 to 1.97), results in some attractive gemstones when cut. Zircon is found as an accessory mineral in many kinds of rocks such as granite, syenite, monazite, and granodiorite. Due to its resistance to weathering, zircon is often found in detrital deposits including placers. No gem-quality zircon has been reported in the state, although zircon has been reported at numerous localities.

CONCLUSIONS

Wyoming is a land rich in its variety of rocks and minerals. It is unique in both its gemstone occurrences and its rare and unusual rocks (Figure 100, Plate 13). It is also a land that is only partially explored and where new gemstone discoveries are being made almost every year.

When the senior author began working for the Wyoming State Geological Survey in 1977, diamonds had just been discovered. Since that time, commercial development and recovery of diamonds has occurred and numerous other mineral discoveries have been made, including the discovery of other kimberlites and the discovery of peridot, iolite, gem-quality pyrope garnet, chromian diopside, and many other unique rocks and minerals. Research by the Wyoming State Geological Survey has greatly broadened our knowledge and understanding of the state's geology, and has resulted in dozens of new discoveries of mineral resources in Wyoming.

The weekend prospector, the vacationer, the museum curator, and the gemologist should all find something of value in Wyoming. It was the intent of this publication to lead you to a variety of collecting localities. We hope this book has increased your perspective of the potential rock and

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INDEX TO LOCALITIES

ABBREVIATIONS AND CONVERSION FACTORS

Chemical symbols

Symbol	*Element*	*Symbol*	*Element*	*Symbol*	*Element*
Ag	Silver	Fe	Iron	Rb	Rubidium
Al	Aluminum	Ga	Gallium	S	Sulfur
Ar	Argon	Ge	Germanium	Sb	Antimony
As	Arsenic	H	Hydrogen	Se	Selenium
Au	Gold	Hg	Mercury	Si	Silicon
B	Boron	K	Potassium	Sn	Tin
Ba	Barium	Mg	Magnesium	Sr	Strontium
Be	Beryllium	Mn	Manganese	Ta	Tantalum
Bi	Bismuth	Mo	Molybdenum	Te	Tellurium
C	Carbon	Na	Sodium	Th	Thorium
Cd	Cadmium	Nb	Niobium	Ti	Titanium
Cl	Chlorine	Ni	Nickel	Tl	Thallium
Co	Cobalt	O	Oxygen	U	Uranium
Cr	Chromium	P	Phosphorus	W	Tungsten
Cu	Copper	Pb	Lead	Zn	Zinc
F	Fluorine				

Platinum Group Elements

Symbol	*Element*
Ir	Iridium
Os	Osmium
Pd	Palladium
Pt	Platinum
Rh	Rhodium
Ru	Ruthenium

Rare Earth Elements

Symbol	*Element*	*Symbol*	*Element*
Ce	Cerium	Pm	Promethium
Dy	Dysprosium	Pr	Praseodymium
Er	Erbium	Sc	Scandium
Eu	Europium	Sm	Samarium
Gd	Gadolinium	Tb	Terbium
Ho	Holmium	Tm	Thulium
La	Lanthanum	Y	Yttrium
Lu	Lutetium	Yb	Ytterbium
Nd	Neodymium		

Conversion factors

1 ounce (oz)	=	31.1 grams
1 ounce (oz)	=	20 pennyweights
1 metric ton (tonne)	=	1,000 kilograms
1 short ton	=	0.907 metric ton or 2,000 pounds
1 ounce per ton (oz/ton)	=	34.3 grams per ton
1 ounce per ton (oz/ton)	=	34.3 parts per million (ppm)
1 part per million (ppm)	=	1,000 parts per billion (ppb)
1 percent	=	10,000 ppm
1 ounce per cubic yard	=	40.7 grams per cubic meter

Miscellaneous

< = less than
> = greater than
lbs = pounds
mi^2 = square mile
yd^3 = cubic yard
°C = degrees celsius

Age

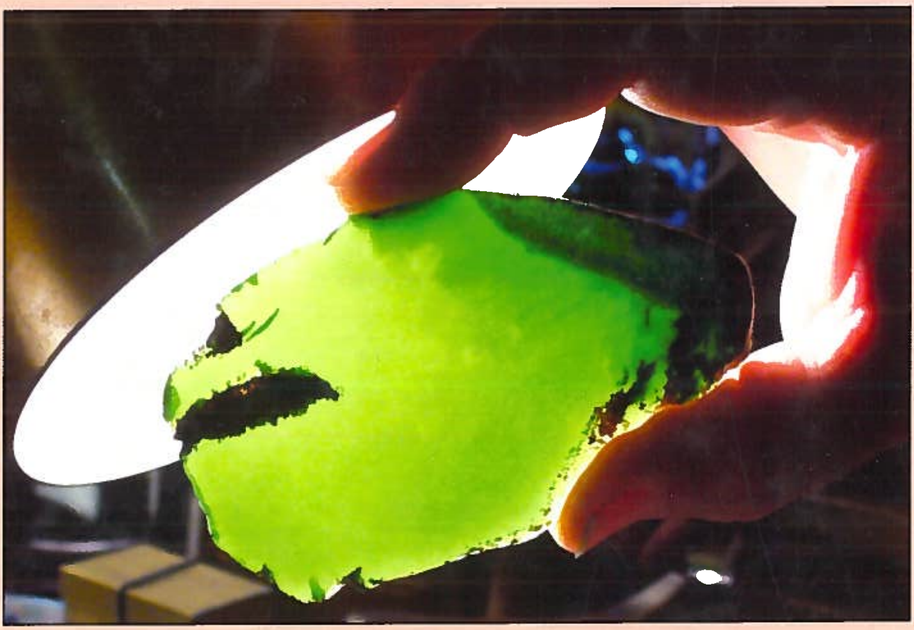
Ga = billions of years (old)
Ma = millions of years (old)

WSGS Bulletin 71

Gemstones and other unique minerals and rocks of Wyoming

A field guide for collectors

Many people consider Wyoming a wide-open frontier, where new mineral discoveries are made every year. Bulletin 71 was written primarily as a treatise on gemstone and related mineral and rock occurrences in Wyoming. Besides the mineralogist and gemologist, mineral collectors and rock hounds who enjoy hunting for rock and mineral specimens and have some background in mineralogy and geology will find this publication of value. It can best be used in conjunction with the maps shown or referenced in the text.



Emerald green Wyoming nephrite jade. *Photo by Wayne M. Sutherland, Wyoming State Geological Survey (2006).*

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