THE GEOLOGICAL SURVEY OF WYOMING
Gary B. Glass, State Geologist

OPEN FILE REPORT 90-9

GEMSTONES, LAPIDARY MATERIALS, AND GEOLOGIC COLLECTABLES IN WYOMING

by

WAYNE M. SUTHERLAND

Laramie, Wyoming
1990

Contents

Introduction 2
Collecting in Wyoming 2
History 4
Alphabetical list 6
Alabaster 6
Amber 6
Barite 7
Beryl 8
Calcite 11
Chalcedony 12
Chromian diopside 30
Corundum 31
Diamond 33
Nephrite jade 35
Opal 39
Quartz (coarsely crystalline) 41
Rocks 43
Selenite 44
Tourmaline 45
Topaz 47
Zircon 47
References cited 47

Introduction

A large variety of gemstones and lapidary materials are found in Wyoming, hosted by rocks ranging in age from Precambrian to Tertiary and by Recent gravels. Some of these, such as diamonds found in the southeastern part of the State, and jade (the Wyoming State Gemstone), found in central Wyoming, are very rare. Others, such as chalcedony and petrified wood, can be found at many localities throughout Wyoming. The localities for gemstones and lapidary materials discussed in this report are described and catalogued to show where they are found and to help identify potential areas for further discoveries. Some of the sites have been known since the early days of Wyoming Statehood, but new occurrences of both gemstones and lapidary materials are constantly being identified.

The term *lapidary* comes from the ancient Greek and Latin term *lapis*, which means stone. A lapidary is an artisan who shapes, engraves, or carves precious stones or gems (Sinkankas, 1962). Lapidary is a broad term, which can encompass any rock or mineral that is cut and shaped, ranging from the most common granite to the rarest sapphire. Gemstones are also broadly defined by their qualities of beauty, durability, and rarity (Sinkankas, 1962). Gemstones include many lapidary materials but exclude the more common materials. The overlap between these two classes of materials leads authors to set their own boundaries for each category.

Gemstones, as discussed in this report, refers to generally accepted precious stones, including beryl (aquamarine and emerald), corundum (ruby and sapphire), diamond, jade, and opal. Semiprecious stones that are valued primarily for their form as crystals or cut crystals such as garnet, quartz, and topaz are also referred to as gemstones in this report. *Lapidary materials*, in this report, will refer to all other rocks and minerals that are commonly cut and polished in a variety of shapes. *Geologic collectables* are rock or mineral specimens that are not suitable for use as gemstones or lapidary materials due to their softness, size, or inability to take a good polish, but are collected for their natural beauty or curiosity.

Table 1 is a list of gemstones, lapidary materials, and geologic collectables found in Wyoming.

Many varieties of lapidary materials, particularly the color variations of chalcedony, are often given local-usage names, which may lead to some confusion. Such names are discussed under the major lapidary material headings.

Collecting in Wyoming

For this report, no attempt has been made to identify ownership of the sites where these gemstones and lapidary materials occur. Before visiting any of these locations, check for land ownership and the existence of mineral claims or leases and obtain permission to enter the land and collect.

Some restrictions apply to the collection of materials from public lands in Wyoming. Land management agencies in Wyoming include The Wyoming kState Land and Farm Loan Office, the Wyoming Recreation Commission, the U.S. National Park Service, the U.S. Bureau of Land Management, and the U.S. Forest Service. Fossils and archeological materials may be protected in general or specifically. Before collecting any such materials, consult with the appropriate land management agency.

Table 1. Gemstones, lapidary materials, and geologic collectables found in Wyoming.

Gemstones	Lapidary materials
Precious stones	Alabaster
Beryl-aquamarine, emerald	Amber
Corundum-ruby, sapphire	Calcite
Diamond	Calcite onyx (onyx marble)
Nephrite jade	Septarian concretions
Opal	Chalcedony(cryptocrystalline quartz)
Semiprecious stones	Agate
Chromian diopside	Bloodstone
Feldspar Group-labradorite	Chert
Garnet Group—almandine, spessartine, pyrope	Chrysoprase
Quartz-amethyst, citrine	Flint
Topaz	Jasper
Tourmaline	Jasperized banded iron fm.
Zircon	Onyx
	Petrified wood
	Sard
Geologic collectables	Ilmenite-magnetite
Barite	
Fluorite crystals	*Rocks*
Gypsum crystals (selenite)	Orbicular granodiorite
Kyanite	Leopard rock
	Fuchsitic quartzite

The collection of materials for commercial use or resale, if allowed by an agency, usually requires a permit or a lease in the case of State lands. In the case of more valuable minerals, regulations governing mining claims or mineral leases may preclude casual collection. If your interests in collecting are more than casual or if the material you wish to collect may have some restrictions, consult with the appropriate land management agency for applicable regulations. The casual removal of gemstones, lapidary materials, and geologic collectables are allowed on State lands administered by Wyoming's State Land and Farm Loan Office. When larger quantities are to be removed or when materials are removed for resale, a lease is required on State-owned lands. For more information on the rules and regulations applicable to lands administered by the State Land and Farm Loan Office contact:

Commissioner of Public Lands
State Land and Farm Loan Office
Herschler Building
Cheyenne, Wyoming 82002

The removal of materials of any kind from Wyoming State Parks, campgrounds, recreation areas, historical sites, or archaeological sites is prohibited without prior permission of the park superintendent (Wyoming State Parks Rules and Regulations, sec. 14, 1986). Inquiries should be addressed to:

Wyoming Recreation Commission
State Parks Division
122 West 25th Street
Cheyenne, Wyoming 82002

No casual collecting of any geologic materials is allowed within the boundaries of any U.S. National Park, National Monument, or National Recreation Area in Wyoming. Part 36 of the Code of Federal Regulations, Chapter 1, Section 2.1 addresses collecting within lands administered by the U.S. National Park Service. Special collection permits may be issued under certain conditions according to the Code of Federal Regulations, Part 36, Chapter 1, Section 2.5. Inquiries should be addressed to the applicable U.S. National Park Service headquarters.

The collection of petrified wood from public lands administered by the U.S. Bureau of Land Management is addressed in the Code of Federal Regulations, Part 43, Subpart 3622. All public lands administered by the U.S. Bureau of Land Management are open to the collection of petrified wood unless otherwise designated. One person is allowed to remove, without charge, a maximum of 25 pounds plus one piece per day using hand tools, not to exceed 250 pounds in one calendar year for personal use only. A permit is required to remove specimens of petrified wood over 250 pounds in weight. A permit is also required to remove more than 250 pounds in one calendar year, to sell the material to commercial dealers, or to use other than hand tools in its removal. Inquiries should be directed to the appropriate area or district office of the U.S. Bureau of Land Management or to:

U.S. Bureau of Land Management
Wyoming State Office
Box 1828
Cheyenne, Wyoming 82001

The U.S. Forest Service may issue a free-use permit for amateur collectors and scientists to take limited quantities of petrified wood for personal use and may issue free-use permits for noncommercial use of mineral materials according to the Code of Federal Regulations, part 36, Subpart 228.62. Some areas may be designated in which a permit is not required. Collection rules vary by area, depending on the quality and quantity of the material and other factors. Before collecting, consult with the local District Ranger of the National Forest in which you wish to collect.

Several maps show the general (and in some cases specific) occurrences of gemstones and lapidary materials within Wyoming and suggest relationships of these to their geologic settings. The *Geologic map of Wyoming* (Love and Christiansen, 1985), *Metallic and industrial minerals map of Wyoming* (Harris and others, 1985), and *Metallic and industrial minerals and lapidary materials map of the Powder River Basin* (Hausel and others, 1990) are available from the Geological Survey of Wyoming and are recommended as useful tools in hunting gemstones and lapidary materials within the State. With a few exceptions, the occurrences of materials described in this report have not been field checked for accuracy of description and location. Some of the localities discussed here exhibit only small amounts of a specific material. However, these locations are an indication that similar deposits might exist in that area.

History

Prehistoric quarry sites are known throughout Wyoming. Quartzite, jasper, and agate were quarried extensively for tool making by prehistoric people north of the North Platte River, in Platte, Niobrara, and Goshen

counties (Cheyenne Mineral and Gem Society, 1965). Such materials have been in use for the last 11,500 years, and have been quarried for 3,000 to 5,000 years (George Frison, personal communication, 1989).

In recorded history, Wyoming's gemstones and lapidary materials received notice in the early 1890s, when masses of moss agate weighing 40 to 50 pounds each were found near Hartville. Table tops made of this material were shown at the 1893 World's Columbian Exposition (U.S. Geological Survey, 1893). Early mining from the Adams Hartville agate mine and from the Wilde and Deercorn mine, both about 2 miles northwest of Guernsey, produced small tonnages of moss agate as late as 1908. A large portion of the material was shipped to the gem cutting region of Idar-Oberstein in Germany (U.S. Geological Survey, 1903, Sinkankas, 1959; Hayford, 1971). In 1903, four and a half tons of this material was sold for $200.00 per ton in Germany (Sinkankas, 1959).

An early newspaper article (Fremont Clipper, 1893) showed an awareness of gemstones in the local area, with perhaps a little exaggeration. This paper listed jasper, agate, cameo, sapphire, amethyst, topaz, moonstone, tiger eye, and opal as occurring in Fremont County. The article also noted one placer diamond was found on Beaver Creek near South Pass.

Keenan (1964) related tales of expeditions sent by German gem cutters to the Sweetwater agate beds along Sage Hen Creek in central Wyoming around the turn of the century. The U.S. Geological Survey (1914) stated that these agate beds had not been commercially exploited as of 1914, and most specimens had been collected by casual visitors, not placed in the regular gem market. Casual collection of Sweetwater agates probably began as early as the 1870s (Love, 1970).

Petrified wood in the Eden Valley area and in Shirley Basin received general attention during the early to mid 1930s. Large pieces of material in the form of logs and limbs were found scattered on the land surface in these areas at that time (Aldrich, 1973; Sunderland, undated). Commercial interests are reported to have removed most of the easily accessible large material within the following few years.

Jade float was discovered in 1936, 48 miles southeast of Lander, by B. A. Rhodes and Al Branham while working in the area. This discovery lead to a Wyoming "jade rush", which continued through the 1950s and opened up the "most important jade area in the Western Hemisphere" (Sinkankas, 1959). Jade has since been found in place at several locations in the Granite Mountains, the Seminoe Mountains, and the northern Laramie Mountains. Jade float has been found over a large area from near Guernsey on the east to the Lander area on the west, with scattered reports of jade from as far south as Rawlins and as far north as Lysite. Wyoming jade, the State Gemstone, is currently sold internationally for its good carving characteristics and its natural beauty.

The interest in Wyoming's gemstones and lapidary materials continues, with active rock clubs in many of Wyoming's towns and cities. A state gem and mineral show is hosted each summer by one of the local clubs. Each summer, an unknown number of serious and casual rockhounds plan their forays in search of lapidary materials, gemstones, and geologic collectables to include at least a part of Wyoming's productive rock-hunting areas.

Alphabetical list

In this report, gemstones, lapidary materials, and geologic collectables are listed in alphabetical order. Regional subheadings (such as Bighorn Mountains or Central Wyoming) for occurrences of a material are also listed in alphabetical order. Locations under each material listing are in order from east to west by township and range within the State or region. This order is occasionally altered when the discussions of several sites or the routes of access to these sites are more logically addressed by a different order. Locations are shown on **Sheet 1**.

Alabaster

Alabaster is a massive crystalline marble-like form of gypsum. This material is extremely soft (hardness = 2) and easily cut, carved, and polished. Colors vary from white to red, yellow, and orange. Limited use has been made of this material in Wyoming, primarily in the form of art objects.

Wyoming alabaster is found in gypsum-bearing formations that crop out along the flanks of many of the major anticlinal uplifts. These include the Permian-Triassic Goose Egg, the Triassic Chugwater (Spearfish), and the Jurassic Gypsum Springs formations.

Alabaster is known from outcrops of the Goose Egg Formation in the Freezeout Hills (secs. 1 and 12, T25N, R80W in Carbon County) (Osterwald and others, 1966). Small amounts of alabaster have been taken from the Goose Egg Forma-tion for use in the bases of sculptures (from W1/2 sec. 29, T45N, R83W in Johnson County).

Osterwald and others (1966) also reported white, yellow, and red alabaster in the lower Chugwater Formation along Little Pope Agie Creek in Fremont County, and in the Spearfish Formation east and north of Newcastle.

Amber

Amber is fossil plant resin produced by a variety of conifers and possibly some flowering plants. It is a soft (hardness = 2-2.5) plastic-appearing material of low specific gravity (about 1.05-1.10) that is easily cut, carved, and polished. Amber has a conchoidal fracture with an oily luster and ranges from almost colorless to yellow, brownish yellow, and reddish yellow. It melts at a relatively low temperature (between 250° C and 325° C). Amber is composed of about 79% carbon, 10.5% hydrogen, and 10.5% oxygen, with a trace of sulfur; its main constituent is succinic acid, $COOH\ (CH_2)_2\ COOH$ (Sinkankas, 1959). When burned, amber gives off an aroma similar to pine. Amber was called electrum by the early Greeks because of its ability to take on an electrical charge when rubbed with wool or a similar material. The use of amber as a gem is limited by its softness, but it has been used for beads and decorations as well as for mouth pieces and pipe stems. Inclusions of insects in amber greatly enhance its value.

Rocks as old as Pennsylvanian are reported to contain fossil resins, although amber-producing plants did not flourish until the Late Cretaceous. In North America in 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 for sealing bark wounds and protecting the tree 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, amber is most commonly associated with sediments characteristic of low-energy depositional environments such as coal seams or carbonaceous shales and silts. Carbonaceous or coaly shales appear to contain better quality amber than coal seams because amber in the coal shows greater fracturing due to compression (J.D. Love, personal communication, 1989). Amber usually occurs as scattered nodules in these types of sediments.

Gem-quality early Eocene amber with a deep reddish brown color was found by J.D. Love in 1934 in the Hanna Formation in the Hanna Basin. A few sizeable lumps of amber have been found associated with Late Cretaceous (Mesaverde equivalent) coaly shale in the Jackson Hole area (J.D. Love, personal communication, 1989). Ed Heffern (personal communication, 1989) reported small pieces of amber were recovered from the Healy coal bed at the east edge of Buffalo in a U.S. Geological Survey (Engineering Geology Branch) drill core hole in May, 1975. The amber reportedly fluoresced. 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 near Gillette (G.B. Glass, personal communication, 1990). Thin seams of amber-like material were reported by Sinkankas (1959) and Glass (1975) from the Fort Union Formation coal beds in Converse County. It is quite likely that amber in small amounts may be found in all of the basins of Wyoming. The coal-bearing rocks of Wyoming and the regions containing them (see Jones, 1990, and in press) suggest areas for the possible occurrence of amber within the State.

Barite

Barite ($BaSO_4$) forms an interesting geologic collectable when found as crystals or crystal clusters rather than granular masses. Barite crystallizes in the orthorhombic system, often forming aggregates or divergent groups of tabular crystals called "barite roses". Its hardness (only 3 to 3.5) precludes any common use as a gemstone. It can be colorless to white, gray, blue, yellow, or red. Luster is transparent vitreous to resinous. Barite is heavy, with a specific gravity of 4.5. It has a perfect basal cleavage with a prismatic cleavage at right angles. Barite occurs as a gangue mineral in metallic veins and with calcite in veins in limestone. Barite is also associated with deposits from hot springs. Barite was reported by Osterwald and others (1966) from scattered areas across Wyoming.

T26N, R75W. Hausel (1986) reported excellent specimens of tabular blue transparent barite from the Sheep Creek area northeast of Medicine Bow. White barite concretions that weakly fluoresce under long-wavelength ultraviolet light are also occasionally found in the Shirley Basin area.

NW sec. 2, T12N, R85W. A pod-like body of barite 40 feet wide by 300 feet long associated with opal (?) was reported by Osterwald and others (1966). The barite occurs along the northern edge of a shear zone in contact with red quartz monzonite.

SE sec. 5, T52N, R102W. Small radial clusters made up of white barite crystals up to one inch across are found here. The barite is associated with hot springs type deposits and solution cavities in the Mississippian Madison Limestone.

Beryl

Beryl (beryllium oxide) commonly occurs as vitreous, white to green, blue-green, and yellow-green hexagonal crystals with flat terminations. The crystals have a conchoidal to uneven fracture with an imperfect basal cleavage that produces the flat crystal terminations. The specific gravity of beryl ranges from 2.66 to 2.9, and it has a hardness of 7.5 to 8. The gem varieties of beryl include deep green emerald and translucent blue aquamarine.

Sinkankas (1959) reported that aquamarine beryl was mined as early as 1906 along with feldspar and mica from the Copper Mountain district southeast of Thermopolis. Beryl has been reported from pegmatites in the Bighorn Mountains, Black Hills, Hartville uplift, Laramie Mountains, Medicine Bow Mountains, and the Wind River Range.

Bighorn Mountains. In 1988, the discovery of aquamarine beryl was reported in the Bighorn Mountains outside of Sheridan. This report has not been verified.

Black Hills. Beryl was reported as a minor constituent in pegmatite dikes in the Mineral Hill area (Smith and Page, 1941). This area includes secs. 21, 28, and 33, T51N, R60W.

Copper Mountain. Beryl, including some gem-quality aquamarine, is found associated with albite and muscovite in pegmatite dikes near Hoodoo Creek on the south side of Copper Mountain. Crystals vary from light green to pale blue elongate euhedral prisms to aggregates of small anhedral blebs. Crystal sizes range from less than 0.034 inch to over 6.8 inches in diameter (McLaughlin, 1940). This area is located in secs. 22, 27, and 28, T40N, R93W (Hausel and others, 1985).

Hartville uplift. Beryl crystals associated with granite pegmatite lenses are found at several localities in the Hartville uplift. None of the beryl has been reported to be of gem quality. Beryl generally makes up less than 1 percent of the pegmatite masses (Millgate, 1965; Wilson, 1951; Sterret, 1923). At least 150 pounds of hand sorted beryl were produced from one location (Millgate, 1965), and crystals up to 4 feet long were reported from another location (Sterret, 1923).

Sec. 1, T27N, R65W. White to light yellowish green beryl crystals 1/4 inch to 1 inch in diameter (most less than 1/2 inch in diameter) are found at this location (Wilson, 1951).

Sec. 14, T27N, R65W. Beryl is found as aggregates in coarse-grained quartz. Approximately 150 pounds of beryl were mined from pegmatite that cropped out at this location (Millgate, 1965).

NE SW sec. 26, T28N, R65W. The Savage claim contains bluish green beryl in a 10-foot-wide pegmatite dike (Sterrett, 1923). Hanley and others (1950) reported that the beryl crystals were from 1/2 inch to 5 inches in diameter, with the average size being less than 1 inch. The beryl usually occurs in clusters of ten or more crystals separated by areas of barren pegmatite.

Secs. 34 and 35, T28N, R65W. The Crystal Palace claim, located on the line between these two sections, exhibits some beryl in a coarsely crystalline pegmatite dike that varies from 6 to 18 feet wide (Sterrett, 1923).

SW NE SE, sec 35, T28N, R65W. Beryl is found in the wall zone of the pegmatite at the Chicago prospect. These light cream to whitish green euhedral crystals range from 1/2 inch to 4 inches in diameter and are often cut by quartz stringers. Some of the beryl crystals have cores of quartz and plagioclase. Similar yellow-white to light green crystals up to 2 inches in diameter and 8 inches long were reported from the Ruth prospect, about 600 feet south of the Chicago prospect (Hanley and others, 1950).

Sec. 35, T28N, R65W. The Minnie claim includes a pegmatite dike, which Sterrett (1923) described as being characterized by beryl crystals 4 feet long. Several other pegmatites in sec. 35 are reported to carry beryl as an accessory mineral (Osterwald and others, 1966).

Sec. 3, T31N, R64W. Beryl crystals up to 6 inches long by 2 inches in diameter are found in a pegmatite at this location, which is up to 20 feet wide and 300 feet long (Osterwald and others, 1966).

Secs. 2 and 3, T31N, R64W. A pegmatite 400 feet long and as much as 90 feet wide contains beryl crystals up to 6 inches in diameter (Osterwald and others, 1966).

Sec. 14, T31N, R64W. Beryl crystals up to 2 inches in diameter and 1 foot long are found in a concordant pegmatite lens in biotite schist at this location. The pegmatite is up to 15 feet wide and 120 feet long, with beryl being more abundant toward its outer edges (Osterwald and others, 1966).

Sec. 34, T32N, R64W. A 60-foot-wide pegmatite in mica schist, extending for a distance of 100 feet, contains sparse beryl crystals up to 3 inches in diameter (Osterwald and others, 1966).

Laramie Mountains. Scattered localities in the northern part of the Laramie Mountains exhibit beryl crystals, primarily as an accessory mineral in pegmatites. Crystal sizes vary from less than 1 millimeter to 4 inches in diameter and 3 feet long.

Secs. 2, 3, 4, 7, 9, 16, 18, and 19, T12N, R72W. Small scattered pegmatite bodies in this area contain rare beryl as an accessory mineral (Hausel and others, 1981).

Sec. 34, T24N, R72W. A tiny aquamarine beryl less than 1 mm in size was identified from a stream-sediment sample taken on Duck Creek (Hausel and others, 1988). The source of the beryl is unknown.

Secs. 9 and 16, T25N, R71W. Small (less than 1 inch) pale blue beryl crystals are found in the Big Chief mica mine. The beryl occurs in fractures in an actinolite schist hanging wall near a pegmatite body (Osterwald and others, 1966).

Sec. 34, T29N, R71W. Two vertical pegmatites extending for a distance of 300 feet, with a width of 2 to 5 feet contain less than 1 percent beryl in their quartz cores. The beryl crystals vary from 1/4 inch to 3 inches in diameter (Osterwald and others, 1966).

Sec. 29, T32N, R75W. The Schundler-Glenrock feldspar deposit exhibits a few beryl crystals in association with pegmatite in granite (Smith, 1953; Osterwald and others, 1966).

Casper Mountain

Secs., 17, 18, 19, and 20, T32N, R79W. White pegmatites consisting primarily of microcline, plagioclase, and quartz host accessory yellow-green beryl. Beryl crystals up to 4 inches in diameter and 3 feet long have been recovered from these pegmatites (Harris and Hausel, 1986). Two tons of hand-picked beryl were shipped from this area in 1956 (Hausel and Glass, 1980).

Medicine Bow Mountains. Three pegmatites in the southern Medicine Bow Mountains contain beryl. However, no gem-quality material has been reported.

Sec. 32, T13N, R78W. The Many Values prospect contains beryl associated with a 15-foot-wide by 150-foot-long exposure of feldspar-cored zoned pegmatite. The beryl crystals are corroded. Two tons of beryl were shipped from the mine prior to 1942 (Osterwald and others, 1966).

Sec. 32, T13N, R78W. The Muscovite claim is located west of the Many Values prospect in a granite pegmatite dike which strikes N50°E, cutting Precambrian metadiabase, hornblende schist, and gneiss. The pegmatite averages 40 feet wide and extends for 600 feet in length. Green beryl is found along fractures in the wall rock associated with tantalite-columbite crystals (Osterwald and others, 1966).

Sec. 32, T13N, R78W. The Ione mining claim is associated with pegmatite west of the Muscovite claim, and is reported by Beckwith (1937) to contain beryl.

T13N, R81W. Beryl is reported by Harris and others (1985) in the Big Creek District on the west side of the Medicine Bow Mountains.

Wind River Range. Beryl has been reported from pegmatites in both the northern and southern parts of these mountains. No mining of these deposits is known to have taken place.

SW sec. 26, T29N, R101W A large specimen of aquamarine beryl was recovered from a tourmaline-beryl pegmatite. The specimen measured roughly 1.5 to 2 feet long by about 3.5 inches in diameter and was extracted in two pieces (W. Dan Hausel, personal communication, 1989).

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

Secs. 3 and 10, T41N, R108W. Beryl was reported from pegmatites adjacent to the Warm Springs fault zone (Osterwald and others, 1966).

Calcite

Calcite ($CaCO_3$) is a relatively soft material with a hardness of 3 and a specific gravity of 2.71. Most calcite is colorless or white, although colors resulting from impurities may include yellow, brown, red, green, pale blue, and violet. Manganese within calcite may give it a pale pink to rose-red color. Some calcite will fluoresce red, pink, white, blue, or yellow under ultraviolet light. Calcite is easily soluble in naturally acidic waters, and will vigorously effervesce in cold dilute hydrochloric acid. Calcite forms rhombohedral or scalenohedral crystals or finely crystalline masses. Limestone and marble are major rock types consisting almost entirely of calcite.

Calcite onyx or onyx marble is similar to cryptocrystalline quartz onyx or true onyx only in its alternating layers of dark and light banding. This material, also called "Mexican onyx" is a massive banded form of calcite. Calcite onyx is deposited from waters saturated with calcite associated with springs in limestone areas. This material does not take as high a polish as true onyx, and is much softer, being easily shaped in carving. Calcite onyx is found in the Guernsey Limestone at several localities in the Hartville uplift, where it has been used both as a decorative stone and a lapidary material. Calcite onyx has also been mined near Cokeville as a decorative stone.

Hartville uplift. Calcite onyx is known from several locations in the Hartville uplift north of Guernsey, and is found in association with both the Permian-Pennsylvanian Hartville Formation and the Mississippian-Upper Devonian Guernsey Limestone.

Sec. 1, T27N, R66W. White calcite onyx has been quarried from the north and south sides of a canyon in the northwest quarter of this section. This material in the Guernsey Limestone extends into the southwest corner of sec. 36, T28N, R66W (W. Dan Hausel, personal communication, 1988).

NE NE sec. 2, T27N, R66W. Brown and white calcite onyx has been quarried from the north side of a canyon (W. Dan Hausel, personal communication, 1988). Brown calcite onyx is also found in an abandoned quarry (the Hartville onyx mine) in the center of the NW1/4 of this section (Eloxite Corporation, 1971). Similar brown calcite onyx is also found on a southeast facing slope of

Guernsey Limestone in the center of the SE1/4 of this section (W. Dan Hausel, personal communication, 1988).

Secs. 10, 11, and 15, T27N, R66W. A band of white, brown, and green calcite onyx extends across SE sec. 10, SW sec. 11, and NE sec. 15. This material, on the north side of Fish Canyon, is associated with the Hartville Formation. Similar calcite onyx in the Hartville Formation is also found on an east facing slope in NE SE sec. 11 and in NE SW sec. 14 on a northeast facing slope (Ray Harris, personal communication, 1988).

SW SE sec. 29, T29N, R65W. Calcite onyx is found on a south facing slope of the Guernsey Limestone (Ray Harris, personal communication, 1988).

Septarian concretions are balls or nodules of clay, silt, and limestone that have been fractured and then recemented with calcite or siderite, so that the cracks have been filled with those minerals. Those concretions are well cemented and are suitable for cutting and polishing in a variety of shapes.

Septarian concretions are reported from outcrops of the Cody Shale in several parts of the state, including both flanks of the Bighorn Mountains and the northern end of the Medicine Bow Mountains. Within the Cody Shale, these concretions are found in the unnamed lower shale member (about 70 feet thick south of Buffalo), the Carlile shale member, and the Niobrara shale member. The upper 90 feet of the Carlile near Buffalo exhibits dark grey fossiliferous limestone concretions averaging 1 foot in diameter with veins of dark orange or yellow calcite. The lower 175 feet of the Niobrara member contains two or three beds of dark yellowish orange, fossiliferous, silty orange septarian concretions with veins of light yellow calcite (Mapel, 1959). The septarian concretions from the Niobrara are up to 10 feet in diameter, although these are generally too fractured for lapidary use.

Bighorn Mountains. Septarian concretions are reported from the Cody Shale on the west side of the Bighorn Mountains near Wyoming State Highways 16 and 14A. Septarian concretions are known from Cody Shale outcrops in several general areas along the east flank of the Bighorn Mountains, including along the west side of Interstate Highway 25 in southern Johnson County near Kaycee.

Sec. 12, T49N, R83W. Mapel (1959) described scattered dark gray septarian limestone concretions at this location in the upper part of the lower shale member of the Cody Shale. These concretions contain marine fossils.

Medicine Bow Mountains. Septarian concretions have been reported in the Niobrara Shale at the northern end of the Medicine Bow Mountains.

Sec. 36, T19N, R82W. Septarian concretions exhibiting black and white calcite are found in the lower Niobrara Shale along the banks of Pass Creek on the northeast side of Coad Mountain (Hayford, 1971).

Chalcedony

Chalcedony is cryptocrystalline quartz including a wide variety and color of materials, most of which are suitable for lapidary purposes. Macrocrystalline varieties of quartz are found under the heading "Quartz".

Chalcedony is actually made up of submicroscopic fiber-like quartz crystals with very small spaces between crystals. These spaces are usually filled with water and possibly air, giving it a specific gravity of 2.58 to 2.64 as compared to 2.65 for quartz. The very fine structure of chalcedony is what makes it so suitable for cutting and polishing. Chalcedony has a vitreous to waxy luster, exhibits a conchoidal fracture, and has a hardness of 7.

Chalcedony forms under near-surface conditions. Chalcedony cannot form at temperatures greater than 300° C, but it can and does form below 100° C (Sinkankas, 1966). Chalcedony is slightly soluble in water, and most likely is formed by the solution and reprecipitation of silica within the sedimentary rocks or other local environment in which it is found. Diatoms and other small sea creatures may have provided the silica available for conversion into chalcedony within Wyoming's Paleozoic limestones, whereas the great quantities of silica found in Tertiary volcanic debris are likely sources for silica contributing to the development of many of Wyoming's agates, petrified woods, and jaspers. Impurities and trace elements incorporated or included within the chalcedony are responsible for the various colors and inclusions that give rise to the different types of chalcedony. In reflected light, the colors of pure chalcedony range from almost colorless to pale shades of blue-gray, whereas in transmitted light the color may be a very pale yellowish brown (Sinkankas, 1966).

The various forms of chalcedony make up the largest and most popular group of lapidary materials. Agate is concentrically banded chalcedony believed to develop as cavity fillings such as in geodes or in fractures to form veins. In common usage, agate refers to chalcedony, which is at least in part translucent. Fortification agate has bandings that make sharp turns resembling the angular parapets of fortresses (Sinkankas, 1966). Moss agate, or more correctly moss chalcedony, is an unbanded chalcedony exhibiting irregular, dark, moss-like or dendritic markings within a light colored translucent matrix. Sard is yellowish and reddish to brown translucent chalcedony. Onyx refers to chalcedony with alternating parallel dark and light layers usually in colors of white or yellow contrasted with black or red. The red and white banded material is called sard onyx. Chrysoprase is an apple-green translucent variety. Jasper is dark red to yellowish brown opaque chalcedony. Prase refers to dull green chalcedony and bloodstone is green chalcedony with red jasper spots. Chert is opaque chalcedony ranging from dull black to gray or white in color. Flint refers to dull gray to black chalcedony. Petrified wood is organic woody material that has been replaced by cryptocrystalline to microcrystalline quartz or opal (Hausel, 1986).

A large variety of names have proliferated around varying patterns and colors of chalcedony, many of which have become well known, while others have very limited local usage. The proliferation of new names for these materials is discouraged. A complete range of color names varying from white to red to golden to black needs no explanation. In addition to the primary names for various chalcedony forms described above, the following names found in literature referring to Wyoming chalcedony are discussed here to help eliminate confusion:

Angel agates are pale greenish gray rounded agates with a chalky white siliceous outer layer of alteration. These agates are found in the upper porous sandstone sequence of the Split Rock Formation in the Granite Mountains (Love, 1970). These agates fluoresce bright greenish yellow under ultraviolet light.

Banded agate is agate containing alternating dark and light layers. Although agates are classically defined as banded, this term often refers to thicker banding or layers within the agate and has been used synonymously with onyx.

Blue Forest wood is petrified wood with a black to brown central area surrounded by clear blue chalcedony (Eloxite Corporation, 1971) characteristic of the Blue Forest area in the Green River Basin.

Botryoidal agate and jasper have an external botryoidal form similar in appearance to a bunch of grapes.

Brecciated jasper appears to be made up of broken pieces that have been recemented with a different colored material.

Cameo is a layered or banded stone such as agate or onyx that has been carved in relief to show a design in one color set off by the background of another colored layer.

Carnelian is synonymous with pale to deep red sard.

Cloud agate has the appearance of cumulus clouds in an otherwise mostly clear background.

Crazy Woman Creek petrified wood is well silicified brown and white banded material found along Crazy Woman Creek in the Powder River Basin.

Dendritic agate is a type of moss agate having a distinctly dendritic pattern to its dark inclusions.

Dryhead agate is a colorful red and white banded fortification-type jasper-agate that weathers out of the Phosphoria Formation in the northern Bighorn Basin. Some of the bands in this material fluoresce green under short wave-length ultraviolet light (Breitweiser, 1966). This agate is named for the Dryhead country, barren headlands which form cliffs above the Bighorn River just north of the Wyoming-Montana state line.

Eden Valley wood is petrified wood characteristic of the Eden Valley and adjacent areas in the Green River and Great Divide basins. This material resembles ordinary weathered wood, having an opaque cream colored outer coating of silica over a center that varies in color from black to brown and gray with some gray streaks in the darker specimens. Most material is smaller than a few inches in diameter and less than 1 foot in length.

Fern agate is synonymous with moss agate.

Flame agate is a red to orange plume agate.

Goniobasis agate is also commonly and incorrectly known as *Turritella* agate. This dominantly brown to black material is part of a well-silicified layer in the Laney Member of the Green River Formation, which contains abundant

Goniobasis gastropod (snail) fossils in southwestern Wyoming. *Goniobasis* gastropods are distinguished from *Turritella* gastropods by their freshwater habitat as well as their shorter (usually less than 1 inch in length) and fatter appearance than the longer and thinner marine *Turritella* gastropods (Breithaupt, 1983).

Guernsey Lake agates include a large variety of agates characteristic of the area around Guernsey Reservoir (Hartville uplift). These include moss agate, jasp-agate, stalactitic agate, youngite, and others.

Heliotrope is an opaque green chalcedony with red spots also called bloodstone.

Iris agate gives a spectral display of colors due to a microscopic diffraction grating structure (400 to 15,000 lines per inch) caused by alternating bands of higher and lower refractive indices. The iris effect is best displayed in very thin translucent slices of rock cut perpendicular to this banding (Sinkankas, 1966).

Jasp-agate refers to chalcedony in which some parts are translucent and some parts are opaque. This is a combination of jasper and agate.

Jasperized banded iron formation is banded iron formation that has been jasperized, producing a very attractive tawny to brown layered rock that is often magnetic. Jasperized iron formation is found along the flanks of Bradley Peak in the Seminoe Mountains. Some samples can be easily cut and polished. This material is also called taconite or ironstone, and less often jaspilite.

Jasperoid is "an epigenetic silicious replacement of a previously lithified host rock" and is commonly a product of hydrothermal alteration of carbonate rocks in mineralized areas (Lovering, 1972). For rockhounds, this translates into a type of chalcedony distinguished from other types by its mode of origin, but which can be cut and polished the same as any other chalcedony.

Jaspilite is the same as jasperized banded iron formation, but the term has been used loosely for other similar appearing materials.

Marshall agates are diverse varieties found in the vicinity of Marshall in the eastern part of the Shirley Basin. These agates include white moss agate, plume agate, black agate, jasp-agate, and others derived from the upper limestones of the Casper Formation.

Montana agate is the same as Yellowstone agate.

Oolitic agate has an internal oolitic structure either as primary silicate or as a replacement of calcium carbonate oolite. Ooids are round accretionary structures 0.5 to 2 mm in diameter having the collective appearance of fish eggs.

Petrified algae is silicified algal mats or colonies that are found in several areas in the Bridger Formation in western Wyoming.

Plume agate has color patterns in tight convolutions having the appearance of ostrich plumes. Also called lace agate or flame agate (when of a red or orange color), these complex patterns can grade into the simpler cloud agate pattern.

Polka-dot agate is a translucent light colored chalcedony containing round dark inclusions having the appearance of polka-dots.

Rainbow agate is the same as iris agate.

Ribbon agate contains thin dark bands that appear as ribbons within translucent chalcedony.

Scenic seam agate has irregular bandings that give the appearance of a landscape within the agate.

Stalactitic agate has roughly circular concentric banding with a small central hole or area of lighter material. The appearance is identical to the cross section of a calcite stalactite.

Sweetwater agates are translucent to opaque, clear to milky white, often wind-polished moss agates characteristic of the central Granite Mountains area of central Wyoming.

Taconite, also known as banded iron formation and ironstone, is a term applied to any bedded iron-rich chert or jasper specifically when the iron content exceeds 25 percent and can, through leaching, be converted into low-grade iron ore (50-60 percent iron). This term is commonly used by rockhounds for any jasperized banded iron formation regardless of its actual iron content.

Tea leaf agate is a gradation between moss agate and ribbon agate having the internal appearance of tea leaves within a translucent chalcedony.

Thunder eggs are agate-filled nodules with a smooth opaque rounded exterior, and generally an internal fortification pattern.

Turritella agate is a term incorrectly applied to *Goniobasis* agate, which is found in the Laney member of the Green River Formation in western Wyoming.

Wiggins Fork agate or petrified wood includes petrified wood, wood casts, and petrified cones and seeds in a variety of colors, occasionally with amethyst-filled centers. This well-known material is characteristic of the Wiggins Fork area north of Dubois.

Wood is a commonly used abbreviation for petrified wood.

Wood casts or limb casts are the chalcedony filling of a form left by the decomposition of wood. This material has the external form of the wood but lacks the preservation of its internal structure.

Yellowstone agates are agates found along the Yellowstone River and some of its tributaries, which originate in the Absaroka Volcanic Supergroup. Also

called Montana agates, these include moss agate, banded agate in various colors, and petrified wood.

Yellow tree agates are brownish yellow agates containing black tree-like dendritic patterns, found northeast of South Pass on the flanks of the Wind River Range. This may not be a true agate since it contains some carbonate (Spendlove, 1984).

Youngite is a light blue to gray or white, weakly banded, occasionally botryoidal and druse-covered chalcedony enclosing a cream to pink and red jasper breccia. This material appears to have formed as cavity fillings in the Guernsey Limestone in the Hartville uplift.

Zebra flint (or rock, stone, jasper, etc.) refers to material streaked or banded in shades of brown or gray. This name is applied to some material found in the Cedar Mountain area in southwestern Wyoming. Zebra stone is a name applied to a carbonate rock found in the Hartville uplift.

Major outcrops of host rocks for Wyoming chalcedony are shown on **Sheet 2**. Chalcedony in Wyoming appears to have two main types of occurrences although other types of occurrences and overlaps between types can be found. The first type occurs as an association with Paleozoic limestones and the second is related to Tertiary volcanic debris.

Detrital material eroded from the Mississippian Madison and Guernsey limestones, and from the Permian Phosphoria Formation along the flanks of many Wyoming uplifts host nodules of agate, jasper, and chert. Silicate layers and nodules within these formations are the most likely source for this chalcedony. The west flank of the Laramie Mountains in the vicinity of Shirley Basin, the west flank of the Bighorn Mountains, and the Hartville uplift all exhibit several varieties of this material. The greatest diversity is found in the Hartville area, but agates there probably have a more complex origin involving several processes and sources of silica enrichment.

Chalcedony that originated in Tertiary volcanic debris either directly or indirectly (through groundwater movement), is the most widely occurring lapidary material in the state. This includes the agates and petrified wood of the Yellowstone and Absaroka volcanics, the Sweetwater agates and several other varieties in the Granite Mountains, and the petrified wood and agates of the Green River and Great Divide Basins. Several major geologic units host agates with this type of origin in central and western Wyoming. The Laney member of the Eocene Green River Formation is well known as the source of *Goniobasis* agate (*Turritella* agate), which is made up of silicified gastropods (Breithaupt, 1983). Silicified mudstones and algal mats are found in the Bridger Formation in western Wyoming (Madsen, 1983). Silicified wood and brown agates are found in central Wyoming (Love, 1970). Love (1970) also described black petrified wood from the Eocene Ice Point Conglomerate and the famous Sweetwater agates found in the Miocene Split Rock Formation in the Granite Mountains area. The Pliocene Moonstone Formation in the Granite Mountains hosts agate pebble reefs in its lower 500 feet and the Pliocene-Pleistocene Bug Formation in the same vicinity is the source of gray and amber agates.

Petrified wood is found in Tertiary deposits throughout most of Wyoming. However, much of this material is highly fractured and/or poorly silicified, which makes it unsuitable for lapidary purposes. Emphasis is given in this

report to material that is suitable for lapidary purposes. Some areas that contain poorer quality (for lapidary use) petrified wood, such as the Dry Creek area in the Powder River Basin, are also mentioned because of interest they generate and their contrast with smaller more workable specimens.

Bighorn Basin. Chert, agate, and jasper from Paleozoic limestone have been found along the east flank of the Bighorn Basin, the southern edge of the Pryor Mountains, and the north side of the Owl Creek Mountains as well as in some of the gravels associated with major drainages from these areas. Wood-cast agates with probable origins related to Tertiary volcanic debris from the Absaroka and Yellowstone regions are reported along the Bighorn River and from drainages on the western side of the Basin. Johnson (1973) reported green agate and crystal-lined geodes along Cottonwood Creek near Hamilton Dome and petrified wood from an area a few miles north of Shell.

Secs. 20, 21, 28, 29, 32, 33, T52N, R88W. Moss agate, chalcedony, and chert are found in the Paleozoic limestones in the vicinity of Spanish Point. George Frison (personal communication, 1989) related that this and similar materials from other locations along the west flank of the Bighorn Mountains were used extensively by Indians for making stone tools. Flakes from such operations are common in many localities.

NW SW sec. 24, T52N, R89W. The Trapper Galloway Ranch, based in Shell, mines dendritic agate from their Jack No. 1 mining claim (Kit Smith, personal communication, 1988).

T45 and 46N, R93 and 94W. Limb cast agates are reported from along the Bighorn River in this area (Keenan, 1964; Johnson, 1973). Root (1977) described these as gray to white agates similar to Wiggins Fork wood, and Keenan (1964) stated that material from the Absaroka and Yellowstone volcanic field can be found in stream terrace gravels up to 200 miles from their source beds.

T58N, R94 and 95W. Dryhead agates were reported by Keenan (1964) and Root (1977) from outcrops of the Phosphoria Formation near the Bighorn River northeast of Lovell. Most of these agates are found north of the Wyoming-Montana state line.

Black Hills. Agates were reported from stream gravels in the Mineral Hill area fifteen miles east of Sundance (Hausel, 1986a). Poor-quality petrified wood is reported from the area southwest of Newcastle.

Sec. 26, T50N, E.62W. A narrow jasperoid zone in the Mississippian Pahasapa Limestone and other silicification is found a few feet above the contact with a Tertiary trachyte porphyry sill. Silicification of the limestone accompanies Pb-Ag-Zn mineralization in the Black Buttes area (Elwood, 1978; Hausel, 1989).

T51N, R60W. Isolated veins and pods of jasper are found in the Cambrian Deadwood Formation, which forms a semicircular outcrop around the Mineral Hill ring-dike complex (Welch, 1974; Hausel, 1989). The Deadwood here is made up of carbonate-rich siltstones, sandstones, and flat-pebble conglomerate on top of conglomerate and quartzite.

Sec. 32, T51N, R60W. Purple chalcedony was found by W. Dan Hausel (personal communication, 1989) in pyroxenite at the Arctic II mine in the north central part of this section. The chalcedony is associated with amethyst crystals and drusy quartz.

Central Wyoming. This area includes the Granite and Seminoe Mountains as well as the Wind River Basin, the east flank of the Wind River Range, and the south flank of the Owl Creek and Bridger Mountains. Central Wyoming includes many well-known and diverse chalcedonies, including the famous Sweetwater agates from the Granite Mountains area. Most agates here are derived from silica sources in volcanic debris. Some agates from the flanks of the Wind River and Owl Creek mountains have origins in outcrops of Paleozoic limestones. The middle part of the Permian Phosphoria Formation, which crops out along the eastern flank of the southern Wind River Range, contains a zone of layered knobby chert with geodes (Bayley, 1965a). Jasperized banded iron formation occurs as float material in a wide area north of the Seminoe Mountains.

Sweetwater moss agates have been collected from this area for 100 years or more. These clear to white, translucent to opaque agates range in size up to 4 inches in diameter, although small pebbles are most common, and they contain black manganese dendrites. Sweetwater agates occasionally have a brown, opaque weathered coating, but most often are water worn, wind polished, and even wind faceted. They are primarily found as lag gravels after weathering out of the basal conglomeratic sandstone of the upper porous sandstone sequence in the Miocene Split Rock Formation. Sweetwater agates fluoresce under ultraviolet light and are sometimes hunted at night with a small portable ultraviolet light (Spendlove, 1982). The agates are thought to have originated northwest of the Beaver Divide in the lower porous sandstone of the Split Rock Formation, which has since been eroded from that area (Love, 1970).

The Ice Point Conglomerate in the Granite Mountains area contains numerous rounded fragments of black petrified wood from unknown sources. The Bridger Formation in the same area contains fossil tree stumps, water-worn fragments of petrified wood, and dark gray and brown agates (Love, 1970). Agates are also found in the Moonstone Formation, the Bug Formation, and gravels along the Wind and Little Wind Rivers.

Chrysoprase has been reported north of Poison Spider Creek in Natrona County and along the south side of Sand Creek (a tributary to Beaver Creek) in Fremont County (Cheyenne Mineral and Gem Society, 1965). The country west of Beaver Creek and north of U.S. Highway 287 is reported to contain petrified wood, agate, and jasper.

Rainbow agates, petrified wood, and jasper are found in gravels all along the Wind River west of Riverton (Osterwald and others, 1966; Hausel, 1986; Johnson, 1973; Ralph Platt, personal communication, 1988). It appears that much of this material was derived from the Wiggins Fork area north of Dubois.

Secs. 18 and 19, T30N, R83W. Agate Basin is the name of this locality on the Oligocene White River Formation, 3 miles northwest of Alcova Reservoir. The derivation of the name is unknown.

Secs. 5, 6, 7, 8, and 18, T26N, R85W. Boulders and cobbles of tawny to brown jasperized banded iron formation are found along Deweese Creek in the Seminoe Mountains and were derived from the Bradley Peak area. Pieces of this material are scattered as float as far east as the Platte River.

SW SE sec. 5, T30N, R87W. A 10-foot-thick conglomeratic layer at the top of the Pliocene-Pleistocene Bug Formation contains dark gray and amber agates (Love, 1970). Some of these agates fluoresce yellow under ultraviolet light.

NW sec. 35, T32N, R88W. Hank Hudspeth Jr. (personal communication, 1989) reported two pods of golden brown and red banded to white jasper in a blowout on his claims.

SW NW sec. 36, T29N, R89W. This is the only known location for "angel agates". These pale greenish gray, 1- to 3-inch diameter agates occur in a 6-inch-thick zone in the upper porous sandstone sequence of the Split Rock Formation about 5 feet below a 10-foot-thick pumicite marker bed. These agates contain a very small amount of uranium (0.006%) and fluoresce a bright greenish yellow (Love, 1970). Angel agates have been quarried from this site for lapidary use.

Ts29 and 30N, R95W. Moss agates are found both up and down stream from where U.S. Highway 287 crosses the Sweetwater River (Johnson, 1973; Bohn Dunbar, personal communication, 1989).

Sec. 20, T32N, R91W. Bohn Dunbar (personal communication, 1989) reported petrified logs in the east central part of this section near Muskrat Creek.

T40N, R90W. Agate was reported from Lysite Mountain by Johnson (1973). Material from this location would most likely be derived from Paleozoic limestones.

Secs. 30, 31, 35, and 36, T38N, R90 and 91W. This general area south of Lysite was reported by Rohn (1986) to contain several varieties of agate including *Goniobasis* (*Turritella* [sic]) agate and petrified wood. The material at this location is all in the form of float, some of which has been wind polished.

Sec. 14, T30N, R90W Agate pebble reefs and bedded chalcedony are found in the lower 500 feet of the Pliocene Moonstone Formation here, and extend into the next two townships to the east. This area is also known as the White Ridge agate beds. The rounded agates, varying from 1/4 inch to 1 1/2 inches in diameter, crop out in low ledges over a distance of about 1 mile. Colors vary from brown to gray in the translucent agates, with a few having moss-like inclusions similar to the Sweetwater agates (Love, 1970). Fossil wood is also found in the Moonstone Formation in this area.

T31N, R90W. Agate flats on the west side of Sage Hen Creek cut across this township in a north-south direction. This is one of the historic areas for gathering of Sweetwater agates. The area has been well picked over in the last 100 years, but a few agates are exposed by erosion each year. Sweetwater agates may be found on or adjacent to outcrops of the Split Rock Formation over an area of about 50 square miles in the north-central Granite Mountains (Love, 1970). These agates have also been reported in gravels many miles down stream along the drainages leaving the area.

Secs. 29, 30, 31, and 32, T28N, R92W. Agates were reported from Crooks Gap by Johnson (1973).

Sec. 23, T28N, R96W. The Bridger Formation, which crops out in this area, contains green silicified algae as well as fossil tree stumps, water worn silicified wood fragments, and brown to dark-gray agates (Love, 1970).

Sec. 3, T31N, R95W. The Beaver Divide Conglomerate Member of the White River Formation crops out along the Beaver Divide, where it contains masses of fibrous chert and irregular beds of chalcedony (Love, 1970).

T4N, R3W (Wind River Meridian). Ralph Platt (personal communication, 1988) reported that good-quality petrified oak has been gathered from the area near Crowheart Butte.

Sec. 25, T31N, R99W. Agates associated with Jurassic sedimentary rocks were reported from this locality (Harris and others, 1985).

Secs. 8 and 9, T30N, R99W. From this general area, Spendlove (1984) described brownish yellow agates containing black tree-like dendritic patterns, which he called Yellow Tree agates. These have an oxidized outer surface and may not be true agates, being at least in part carbonate.

SW sec. 14, T30N, R99W. Jasper was reported from the Amsden or Phosphoria formations by Hank Hudspeth Jr. (personal communication, 1989). This material has an irregularly banded red and golden brown color and takes a high polish.

Sec. 25, T32N, R101W. Clear to gray botryoidal to stalactitic agate is found in the Bighorn Dolomite. This material occurs as loose debris on the slopes of Fossil Hill (Gary B. Glass, personal communication, 1989).

Hartville uplift. The Hartville uplift contains the greatest variety of chalcedony types of any area in the state. Moss agates were mined here during the late 19th and early 20th centuries. The Mississippian Guernsey Limestone here is the primary host for jaspers varying in color from red and purple to brown and yellow, as well as for moss agate, stalactitic agate, youngite, and several other color and pattern variations. Much of this material is found as float in addition to its occurrence as nodules, seams, and fracture fillings, in the Guernsey Limestone. The Pennsylvanian-Permian Hartville Formation in this area contains jaspers and fortification agates.

T28N, R65W. Brown chert nodules up to 1 foot in diameter are found in the hills of the Hartville Formation in NW sec. 5 and NE sec. 6. These nodules, when cut open, exhibit colorful fortifications in bands of red to brown, white, gray, and clear agate (Ray Harris, personal communication, 1989).

N 1/2 NE sec. 26, T28N, R65W. Jasper was found here (W. Dan Hausel, personal communication, 1988).

T30N, R65W. Jasper was found in the Hartville Formation at the center of the line separating secs. 6 and 7 (Ray Harris, personal communication, 1988).

Center N 1/2 and SW NE sec. 36, T32N, R65W. Youngite occurs in this section (Ray Harris, personal communication, 1988).

NE sec. 2, T27N, R66W. Moss agates, similar to Sweetwater agates are present as float on the hill above the Hartville onyx mine (Eloxite Corporation, 1971). Jasper is also present near the mine.

Secs. 6, 7, 8, 9, 10, 15, 16, 17, 18, 19, 20, 21, 22, 26, and 27, T27N, R66; and secs. 1, 12, and 13, T27N R67W. The shores and cliffs surrounding Guernsey Reservoir exhibit several varieties of chert and chalcedony, which are often found as detrital material near the lake. These materials include red and purple jasper, youngite, and some fortification agates (Hayford, 1971).

NW sec. 24, T27N, R66W. This section contains agate and jasper (W. Dan Hausel, personal communication, 1988).

Sec. 25, T27N, R66W. The Adams Hartville agate mine is located near the top of a hill in the center of this section (Eloxite Corporation, 1971). This appears to be the same mine referred to as the Wilde and Deercorn mine by the U.S. Geological Survey in 1908. This mine was responsible for most of the reported moss agate production from the Hartville area. Production reports are sketchy; U.S. Geological Survey figures indicate 2 tons 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. This agate will fluoresce bright green under ultraviolet light. The Guernsey Limestone here contains some lower quartzite beds and rests unconformably on Precambrian quartzites, phyllites, and schists (U.S. Geological Survey, 1908). Moss agate was mined around the turn of the century from an irregular vertical vein that varied from 1 inch to 2 feet in thickness, and cross cut the Guernsey Limestone. Red banded agate has also been reported from this location. About 200 yards north of this mine are copper prospects reported by the Eloxite Corporation (1971) to contain some brown jasper with bright blue streaks of chrysocolla (hydrous copper silicate).

SW NE NW sec. 22, T28N, R67W. Youngite is found on a southeast facing slope on the north side of Sawmill Canyon.

SW sec. 36, T28N, R67W. Youngite was mined from cavities in the Guernsey Limestone on the north side of the Platte River. The majority of this deposit is in the form of a cave fill and is protected from mining by the National Cave Resources Protection Act of 1988 and other State and Federal laws.

Ts30 and 31N, R66 and 67W. Fortification agates are reported from the vicinity of Spanish Diggings in this area (Eloxite Corporation, 1971). Ray Harris (personal communication, 1988) described the entire area of northeast Platte County and southwest Niobrara County as being covered with small agates that have weathered out of the Hartville Formation. In this same area, an orthoquartzite occurs just above the Morrison Formation. Where the material was solid and uniform in its composition, cobbles of this orthoquartzite were mined by Indians in and around Spanish Diggings for stone tools and weapons (Ray Harris, personal communication, 1989).

T30N, R67 and 68W. Several varieties of agate and jasper are found on the shores of Glendo Reservoir and in the surrounding country (Hayford, 1971; Eloxite Corporation, 1971). These include golden brecciated jasper; white stalactitic agate; red, pink and white scenic seam (irregularly banded) agate; polka-dot agate; black moss agate; and butterscotch colored agate. The source

for these materials appears to be the Hartville Formation and the Guernsey Limestone.

Secs. 33 and 34, T32N, R69W. Chalcedony veins and some associated uranium mineralization were reported by Guilinger (1956) in steeply dipping northeast-trending fault zones in the Oligocene White River Formation. Some translucent chalcedony contained a yellow uranium mineral, and other chalcedony not visually exhibiting mineralization was radioactive. Most of the chalcedony exhibited yellow-green fluorescence under short-wavelength ultraviolet light. Uranium mineralization appears to post-date the development of the chalcedony. Gruner (1955) reported similar chalcedony in sec. 28 of this township. He further noted that the silicified fault zones form discontinuous sharp ridges up to 30 feet wide across the south half of this township and also contain some quartz and opal.

Northwestern Wyoming. Northwestern Wyoming is dominated by the Eocene Absaroka Volcanic Supergroup, which includes the Wiggins Formation, consisting of light gray volcanic conglomerate and white tuff containing clasts of igneous rocks, and the Wapiti Formation, which is made up of andesitic volcaniclastic rocks. These rocks, spread widely across the eastern border of Yellowstone Park in the Absaroka Mountains, are a treasury of petrified wood and agates. Yellowstone Park is famous for its fossil forests in the northeastern part of the park. Silicified trees are common in the Specimen Ridge and Amethyst Mountain areas, where some prostrate trunks can be found up to 50 feet in length, and some specimens are as much as 5 feet or more in diameter (Sinkankas, 1959). Mineralogic descriptors applied to geographic features within the park such as geode, agate, quartz, jasper, and others indicate the abundance and diversity of such materials. Although **no collecting is allowed within the boundaries of Yellowstone National Park** without a special research permit, similar materials can be found outside of the park, and some of these areas are open to collection. Petrified wood in the form of silicified logs, trunks, and stumps is found in many areas and includes upright pieces that resemble burned-out modern forests. Wood casts, fossil cone casts, agatized seeds, and oval nodules are also common. 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. The oval nodules may be remnants of chalcedony-filled vesicles in lava or scoria beds (Keenan, 1964). These materials include the well-known Wiggins Fork agates and petrified wood and the Montana agates, which are found along the Yellowstone River as far east as Glendive, Montana.

T45N, R106W. This township, including the Wiggins Fork and Frontier Creek, is the center of attention for rock hounds seeking Wiggins Fork petrified wood and agate. These materials are abundant in the Wiggins Formation, which covers most of this and many of the surrounding townships. **Some areas are closed to collection.** Collectors should check with the Shoshone National Forest office to find out where collecting is allowed.

Ts43 and 44N, Rs107 and 108W. Debris from the Wiggins Formation, including petrified wood and agate, can be found as terrace and stream gravels in these townships. Horse Creek, Burrows Creek, and many of the streams feeding DuNoir Creek have all been reported as good collecting localities (Cheyenne Mineral and Gem Society, 1965). Volcanic deposits other than the Wiggins Formation may contribute to the petrified wood and agates found in this area.

Limited exposures of Paleozoic carbonate rocks may also supply some forms of chalcedony.

T54N, R104W. Jasperoid is found in the western part of this township in Paleozoic sedimentary rocks (Nelson and others, 1980; Hausel, 1989). This occurrence is east of the Sunlight mineralized area along the eastern edge of the Absaroka volcanics.

Powder River Basin. The most common form of chalcedony in the Powder River Basin is petrified wood, although chert and jasper detrital material is associated with Paleozoic limestones that crop out along the flanks of the Bighorn Mountains on the west side of the basin (Hausel and others, 1990). Moss agates have been reported from the basin between Fort Reno and Crazy Woman Creek (Cheyenne Mineral and Gem Society, 1965). The majority of the petrified wood is found in the Eocene Wasatch Formation and occasionally exhibits itself as spectacular large-diameter stumps and logs such as those found east of Buffalo at the U.S. Bureau of Land Management's Dry Creek Petrified Tree site. Although occasionally quite impressive, this wood is poorly silicified, quite brittle, and crumbles easily into small pieces that are not even suitable for tumble polishing.

Another type of wood, known as Crazy Woman Creek petrified wood, is much more durable and is well suited to lapidary purposes. Crazy Woman Creek 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 near the Bighorn Mountains flank to where Dry Creek joins Crazy Woman Creek. Large pieces of Crazy Woman petrified wood up to 18 inches in diameter and 16 inches long were collected from the vicinity of Crazy Woman Creek in the past and can be found in landscaping and in local collections in Buffalo. Material similar to Crazy Woman wood is found in terrace gravels along the Powder River from near Kaycee to where U.S. Highway 14 crosses the river.

S 1/2 sec. 24, T48N, R81W. Partially rounded cobbles of Crazy Woman Creek petrified wood ranging in size from 3 inches to over 10 inches in length have been found in piles of over-sized material rejected from a gravel pit.

NE sec. 31, T48N, R81W. Chunks of Crazy Woman Creek petrified wood up to 6 inches in length have been found near an old gravel pit.

Secs. 30 and 31, T51N, R80W. Numerous petrified trees and logs are found at this location between the Healy and Walters clinker/coal beds in the Wasatch Formation. This wood is poorly silicified. The U.S. Bureau of Land Management maintains a withdrawal area (no collecting allowed) in sec. 31 to allow visitors to see some impressive petrified remains of an Early Eocene forest. Durkin (1986) identified these trees as being primarily cypress and sequoia, with some specimens as large as 3 feet or more in diameter and 12 feet tall.

Southeastern Wyoming. Southeastern Wyoming as described here includes the Laramie Mountains, Shirley Basin, Laramie Basin and the Saratoga Valley, and extends as far west as the Rawlins uplift. This area contains several types of chalcedony, including petrified wood, which may have its source of silica in late Tertiary volcanic debris. However, the most common forms of chalcedony in this part of the State are agates and jaspers derived from Paleozoic limestones, particularly the Pennsylvanian-Permian Casper Formation. This

type of material is extremely varied in its appearance, and includes several colors of jasper, jasp-agate, white moss agate, black agate, and carnelian agate.

T22N, R66W. Johnson (1973) reported dendritic agates from the hills near Slater. These agates probably come from either the Oligocene White River Formation or the lower Miocene/upper Oligocene Arikaree Formation. Both formations contains tuffaceous material, which could indicate a volcanic silica source for these agates.

Secs. 25, 26, 35, and 36, T15N, R70W. Carnelian reported from the vicinity of Table Mountain (Osterwald and others, 1966) was probably derived from the Casper Formation.

Secs. 16 and 21, T12N, R76W. Botryoidal agate and jasper were found around the base of Red Mountain (Muriel Forney, personal communication, 1988). These agates and jaspers are derived from outcrops of the Casper Formation along the mountain flank.

Sec. 28, T19N, R70W. About 4 miles north of Farthing and one-half mile east of the road, clear polka-dot agates, crinoid stems embedded in jasper, and jasper thunder eggs can be found (Hayford, 1971). The source for this material is not known.

Sec. 22, 23, 26, and 27, T19N, R71W. The October, 1973 issue of *Gems & Minerals Magazine* reports that agates and jasper can be found on or near Iron Mountain. According to Ralph Platt (personal communication, 1988), these were derived from the top of a limestone bed that also contains trilobites. These agates are similar in appearance to Dryhead agates.

NE sec. 3, T22N, R73W. Jasper and agate associated with the Casper Formation are found north of Wheatland Reservoir No. 2 (W. Dan Hausel, personal communication, 1988).

Secs. 35 and 36, T24N, R74W. Clear to blue-gray and black, lightly banded, botryoidal agate and moss agate are found in the Casper Formation in this area (Alan Hinman, personal communication, 1988). Some pieces are of a stalactitic form and exhibit concentric banding. Reddish brown jasper is also found at this location.

Sec. 10, T26N, R75W. The surface of Casper Formation limestone at this location exhibits reddish brown to yellowish brown jasper as well as clear to blue-gray and black chalcedony, some of which exhibits a natural polish. Much of the material is botryoidal in form, and the agates fluoresce green under both short- and long-wavelength ultraviolet light. The deep, sometimes metallic black appearance is due to the presence of manganese, which at one time was mined from the Casper Formation.

T27N, R75W. Jasper and white moss agate are found in the Casper Formation near Marshall and in gravels southwest of Marshall (Hausel, 1986). Other types of agate found in the Marshall area include jasp-agate, black agate, plume agate, and brecciated jasper.

Sec. 19, T28N, R76W. This general area of Casper Formation outcroppings is known as Specimen Hill. Numerous varieties of agate have been collected

from this vicinity including plume agate, banded black agate, dendritic agate, and jasper.

Sec. 23, T31N, R74W. Moss Agate Hill adjacent to Moss Agate Creek hosted moss agates in the past. The hill has been essentially picked clean and few if any agates remain (Osterwald and others, 1966).

Sec. 6 and 7, T32N, R74W; and secs. 1 and 12, T32N, R75W. Chalcedony layers and crystalline quartz within geodes occur in sandstones and limy sandstones in Box Elder Canyon (Osterwald and others, 1966).

T22N, R77W. Silicified dinosaur bones are found on both sides of Como Bluff north of U.S. Highway 287/U.S. 30 (Sinkankas, 1959). A cabin made of this material can be seen at Como next to the highway. The Cheyenne Mineral and Gem Society (1965) reported agatized wood fragments can be found on both sides of the Como Bluff anticline.

T27N, R78W. This township and the surrounding areas of Shirley Basin have been known as a source of petrified wood since the 1930s. Humid subtropical woods such as palms and other species once grew here, as demonstrated by a forest of silicified logs and fallen trees with diameters up to 3 feet or more in the Eocene Wind River Formation. The majority of this wood was hauled away by commercial collectors between the 1930s and 1950s (Sunderland, undated). The wood ranges in color from white to brown and black, and is generally of poor quality, breaking easily into small flakes.

Sec. 32, T28N, R78W. Moss Agate Reservoir is located in this section on the Eocene Wind River Formation below a ridge of Oligocene White River Formation. That ridge, which extends to the west for about 3 miles, is called Moss Agate Ridge. The exact type and origin of the agates that gave rise to these names is not known.

Sec. 1, T14N, R79W. A fault crossing this section and extending into sec. 6, T14N, R78W is marked by a narrow breccia zone that contains abundant irregularly shaped masses of blue-gray to white opaline chalcedony. The fault, on the east edge of the New Rambler Cu-Ag-Pt district, cuts Sherman type granite and the adjacent mylonitic gneiss is postulated to be of Laramide age (McCallum and Orback, 1968).

Sec. 33, T15N, R79W. A porous, spongy limonite "jaspilite" gossan overlies a 75-foot-thick oxidized zone that caps the classical supergene enriched ore body at the New Rambler mine (Hausel, 1989; McCallum and Orback, 1968). This may be a silicified or partially silicified iron gossan rather than a true jaspilite. The mine is located in the SW1/4 of this section.

Secs. 1, 2, 3, 10, 11, and 12, T18N, R84W, and secs. 24, 25, 26, 27, 34, 35, and 36, T19N, R84W. Agatized wood and dendritic agate are found on the flats along Wyoming State Highway 130 about 14 miles south of Walcott Junction. The host rock for this material appears to be tuffaceous sandstones, siltstones, and claystones of the Miocene North Park Formation. The volcanic material in this formation probably contributed to the development of this chalcedony.

Ts33 and 34W, Rs81 through 85W. In this general area, carnelian agate has been reported between Poison Spider Creek and South Fork Casper Creek (Osterwald and others, 1966).

Secs. 9, 10, 15, 16, 21, and 22, T22N, R88W. Carnelian agate is found in this general area of the Rawlins uplift (Harrison Cobb, personal communication, 1988). The host rock for this material is not known.

T18N, Rs88 and 89W. Lovering (1972) reported jasperoid in the Miller Hill area about 25 miles south of Rawlins in association with localized concentrations of uranium ore. Thin (3- to 10-foot-thick) fresh-water limestone beds within the Miocene Brown's Park Formation have been locally brecciated and replaced with silica. The silica was apparently leached from porous tuffaceous sandstone and then precipitated in the limestones by the action of ground water.

Southwestern Wyoming. Southwestern Wyoming, including much of the Great Divide, Washakie, and Green River Basins, contains widespread chalcedony. Petrified wood of the Eden Valley type and petrified algae and *Goniobasis* agate are all found in this part of the State. Eden Valley petrified wood is found spread over a wide area centered around Farson. The Laney Shale Member in the upper part of the Green River Formation and the overlying Bridger Formation, both of Eocene age, appear to be sources of this material. During Eocene time, a large inland lake, Lake Gosiute, filled much of the Green River Basin and resulted in the deposition of the extensive lacustrine deposits of the Green River Formation. The greatest extent of this lake covered almost 15,000 square miles, and occurred during deposition of the Laney Shale Member (Bradley, 1964). During the deposition of the Laney, which is primarily represented by tuffaceous buff chalky to muddy marlstone and brown to gray shale, the climate was warm and moist. Under these conditions, hardwood trees, pine, fig, magnolia, and other types flourished in widespread heavily forested swampland cut by numerous braided streams. Lake Gosiute expanded and contracted in response to periods of increased precipitation alternating with dry spells. These fluctuations 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 with silica leached from the volcanic material. Later erosion exposed this silicified wood as well as silicified algal and oolitic limestones and layers of *Goniobasis* snail shells Bradley, 1964). Much of this chalcedony is found as pebbles and fragments scattered across the desert, where wind erosion has removed the fine materials surrounding them.

The overlying Bridger Formation is primarily fluviatile, with some thin lacustrine layers, and contains locally silicified limestones and marlstones. Petrified wood is common in the Bridger Formation, particularly in the vicinity of Oregon Buttes (Bradley, 1964). Much of the petrified wood is encrusted with algae, silicified by processes similar to those that petrified materials in the underlying Laney Shale.

Much of the Eden Valley wood that has been exposed to weathering for long periods of time is reported to loose its ability to take a high polish (Cheyenne Mineral and Gem Society, 1965). In addition, some materials are incompletely silicified. For these reasons, lapidaries search for choice quality material in fresh exposures caused by recent erosion or they dig below the

ground surface hoping to find such material. Extensive digging by rockhounds has left many areas pockmarked with shallow holes.

Reefs and beds of silicified *Goniobasis* gastropods, which were deposited only at certain depths within the lake, are found throughout the area formerly covered by Eocene Lake Gosiute. Not all occurrences of *Goniobasis* (or any other materials) were equally silicified. Some *Goniobasis* agate that is light brown in color and appears weathered does not take a good polish. The agate in shades of dark brown to black takes a polish well and is the material most sought after by experienced rockhounds.

Ts17 and 18N, R93W. Petrified wood in a variety of colors has been found in these townships along the road between Wamsutter and Baggs near the Continental Divide (Cheyenne Mineral and Gem Society, 1965; Johnson, 1973).

Ts16 and 17N, Rs95, 96, and 97W. A range in this area called the Haystack Hills is the source for several types of agate including petrified wood, oolitic agate, and petrified algae (Ralph Platt, personal communication, 1988). These agates appear to occur in the Eocene Washakie Formation.

T17N, Rs94, 95, 96, and 97W This broad area is mostly underlain by a large outcrop of the Laney Shale Member of the Green River Formation, which is well known as a source of *Goniobasis* agate. In addition to the *Goniobasis* agate, oolitic agate, petrified algae, and petrified wood are known from this area.

T18N, R96W. *Goniobasis* agate is reported along with oolitic agate and petrified algae from a broad area in the western part of this township (Eloxite Corporation, 1971; Johnson, 1973).

Sec. 9, 10, 11, 15, and 16, T23N, R102W. Agate and chalcedony were reported on the slopes of Steamboat Mountain by Sinkankas (1959). Wilson (1965) further described the material as chalcedony-lined amygdules ranging in length from 3 to 6 inches. These amygdules are contained within 1.25-million-year-old lamproite (orendite and wyomingite) lava flows that cap the mountain.

Ts26 and 27N, Rs100 and 101W. The area around the juncture of these four townships east of Oregon Buttes is known as a source of Eden Valley petrified wood (Sinkankas, 1959; Eloxite Corporation, 1971). The characteristic dark petrified wood is probably a product of the Laney Shale Member of the Green River Formation or the overlying Bridger Formation. This is the easternmost area 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 further reported much of this wood to be surrounded with a covering of silicified algae. Bradley (1964) also reported silicified algal and oolitic limestone from the Laney Shale Member of the Green River Formation in sec. 2, T26N, R101W.

Secs. 1, 2, 11, and 12, T25N, R103W. Eden Valley petrified wood has been collected from this area on the Hay Ranch. The area is pockmarked with holes left by rockhounds digging for petrified wood (Cheyenne Mineral and Gem Society, 1965) and contains exposures of the Laney Shale Member of the Green River Formation.

Ts18 and 19N, Rs108 to 111W. *Goniobasis* agate was reported by Hausel (1986) to cap buttes in the area between Green River and Granger. Silicified algae is also found capping these buttes (Sinkankas, 1959). The agate layers, which cap the buttes because of their resistance to erosion, are found within either the Laney Shale Member of the Green River Formation or in the overlying Bridger Formation.

T23N, R109W. The Cheyenne Mineral and Gem Society (1965) described the south half of this township as a source of several types of petrified wood, which are found in the "blue beds" that cover much of the area. These "blue beds" appear to be part of the Bridger Formation.

T27N, Rs105 and 106W. The center of T27N, R105W northeast of Big Sandy Reservoir was reported by the Cheyenne Mineral and Gem Society (1965) to have been the target area for numerous rockhounds searching and digging for Eden Valley petrified wood. The areas a mile or two both east and north of Big Sandy Reservoir were reported in *Gems & Minerals Magazine* (July, 1976) as collecting localities for petrified wood and algae.

Ts26 and 27N, R107W. Sublettes Flat, which covers a wide area in these townships west of Big Sandy Reservoir, hosts small limb casts of milk-white agate. These agates occasionally contain an internal tube-like structure and may exhibit an iris agate display of colors (Cheyenne Mineral and Gem Society, 1965).

Secs. 2 and 19, T14N, R110W; sec. 22, 24, and 25, T14N, R111W; and sec. 23, T15N, R111W. Mitchell (1984) reported finding several varieties of chalcedony at these locations. The wide spread of these localities indicates that much of the surrounding area, all of which is made up of Bridger Formation, may yield similar materials. Materials found here included agate, jasper, jasp-agate, flint and chert. The flint and chert, some of which is called zebra flint due to its white, brown, and black stripes, may be debris from the Oligocene Bishop Conglomerate, which caps Cedar Mountain on the west and south. The jasp-agate here is red and yellow with white and blue streaks and the jasper is bright orange and yellow. Agates are multicolored to black with moss, flame, and plume patterns.

T15N, Rs111 and 112W. W. Dan Hausel (personal communication, 1988) reported that agates, chert, and jasper are found across the centers of these townships in the Bridger Formation.

T13N, R113W. Outcrops of white beds in the Bridger Formation in the west-central and northwest part of this township exhibit occasional irregular bands of black and brown chert (Bradley, 1964).

Sec. 19, T13N, R113W. Madson (1983) reported silicified gastropods to be found in this area of the Bridger Formation.

Secs. 6 and 7, T14N, R113W; and sec. 2, T14N, R114W. Silicified algal mats and silicified mudstones were reported from this area by Madson (1983).

Sec. 1, T16N, R114W, and sec. 32, T17N, R113W. Moss Agate Cut is a place name at this locality in the Bridger Formation.

Sec. 1, T18N, R112W. Moss Agate Knoll is a place name in this section, which includes outcrops of the Bridger Formation.

T21N, R111W. Petrified wood and agate were reported from the Whiskey Basin area by Johnson (1973). This area is an exposure of the Bridger Formation.

Secs. 2, 3, 8, 9, 15, and 16, T23N, R110W, and secs. 34 and 35, T24N, R110W. These general areas, made up mostly of Bridger Formation exposures, are reported by Mitchell (1982) to contain several types of chalcedony. Yellow and brown jasper and petrified wood are both found in these areas. Some of the wood and agates found here have a blue color. The majority of the agates are multicolored, and a wide variety can be located.

Secs. 28, 29, 30, 31, 32, and 33, T24N, R110W. This is the Blue Forest, which derives its name from being the source of Blue Forest petrified wood. This wood is a clear blue color surrounding a black or natural wood colored central area. Some blue wood also contains white fortifications (Eloxite Corporation, 1971).

T20N, Rs112 and 113W; and T21N, Rs112, 113, and 114W. The Cheyenne Mineral and Gem Society (1965) and Sinkankas (1959) reported abundant agate in the badlands along the Hams Fork. These large areas contain extensive exposures of the Bridger Formation and the Laney Shale Member of the Green River Formation.

T19N, R117W. This area, south of Kemmerer, is reported to contain agate and petrified wood (Johnson, 1973). The source for these materials is unknown.

Chromian diopside

Chromian diopside is a bright emerald-green or Christmas-green chromium-rich variety of diopside [$CaMg(SiO_3)_2$]. Its exceptional green color is due to the presence of chrome substituting in part for magnesium in this member of the pyroxene family of minerals. Chromian diopside has a hardness of 6 and a specific gravity of 3.20 to 3.40. It is transparent to translucent with a vitreous luster. Its excellent cleavage and parting result in the formation of rough rectangular grains. Chromian diopside is an indicator mineral for the location of kimberlites. Exceptional specimens have been cut and polished as semiprecious gemstones.

Chromian diopside is found along with other heavy minerals such as pyrope garnets associated with kimberlites in the Colorado-Wyoming kimberlite province (see Diamonds; Garnets) and in heavy-mineral anomalies in the Laramie Mountains. None of the material found in this area has been gem quality.

Detrital grains of chromian diopside up to 6 mm diameter were reported by McCandless (1982) along with other heavy mineral grains such as pyrope garnets from ant hills north of Cedar Mountain in the Green River Basin (T15N, R111 and 112W). Many of these chromian diopside grains and associated pyrope are gem quality, and they have been cut and polished locally (W. Dan Hausel, personal communication, 1989). These chromian diopside grains and related minerals found in ant mounds decrease in abundance to the north,

east, and south until they are no longer present. The ant hills themselves disappear to the west. No source has been found for these heavy minerals.

Chromian diopside grains have also been reported in the vicinity of Granger (W. Dan Hausel, personal communication, 1989).

Corundum

Corundum is aluminum oxide (Al_2O_3), and its hardness of 9 is second only to diamond. Corundum as a gemstone is better known as the intense red ruby or the blue sapphire. The term ruby is restricted to pure, deep red corundum, while the term sapphire applies to all other colors including pink, purple, clear, blue-green, and blue (Sinkankas, 1959). The deep red color is caused by chromium within the corundum crystals, and the blue color is related to the presence of iron and titanium. The luster of corundum is adamantine to vitreous, and less commonly translucent to transparent. Asterism or stellate opalescence seen in the direction of the c crystal axis results in the term star ruby or star sapphire. The asterism may be due to the presence of microscopic rutile needles within the crystal (Deer and others, 1966).

The specific gravity of corundum is 4.0 to 4.1. Crystals are usually prismatic with a hexagonal outline, varying in shape from short stubby barrel forms to flattened wafer-like shapes, which appear to be more prevalent in rubies than in sapphires. Basal and rhombohedral partings are usually well developed, with triangular markings common on the basal plane in rubies. Striations, when present, are caused by repeated twinning.

Corundum occurs as an accessory mineral in some metamorphic rocks such as mica schist, gneiss, and crystalline limestone. It is also found in some silica-deficient igneous rocks such as syenites and nepheline syenites. Minerals associated with corundum include chlorite, micas, olivine, serpentine, kyanite, spinel, magnetite, and diaspore (Hurlbut, 1966).

Sapphires up to 1/2 inch in diameter have been mined in Montana intermittently since the late 1800s, and Montana is the only major producer of sapphires in the U.S. The Montana sapphires occur both in alluvial deposits, such as those found at Rock Creek west of Philipsburg, and as lode deposits, in and near Yogo Gulch east of Helena. Blue sapphires are the exception rather than the rule on Rock Creek whereas the "cornflower blue" lode sapphires mined from the Yogo Gulch area are rarely interspersed with other colors (Voynick, 1987a, b). The Yogo Gulch sapphires are mined from a narrow (2 1/2 feet) Tertiary lamprophyre dike intruded into Paleozoic limestone (Brownlow and Komorowski, 1988).

Wyoming corundum is not common but it has been found in the Granite Mountains, in the Laramie Mountains, and in the Medicine Bow Mountains. A few gem-quality specimens have been reported, although most rubies and sapphires collected in Wyoming have been poor quality.

Granite Mountains.

Ts27 and 28N, Rs90 and 91W. Hausel (1986) reported an excellent specimen of ruby schist float collected from the Green Mountain area by Avon Brock. The schist had several deep red rubies ranging up to thumbnail size, however, the source area for the material was never found.

Sec. 20, T32N, R91W. Soft green mica schist boulders in the Wind River Formation containing dark red rubies were reported by Love (1970). The rubies were up to 1 inch in diameter, but were badly fractured.

NE sec. 13, T30N, R93W. According to Love (1970), rubies in Precambrian mica schist were found in this section. Most of the rubies were highly altered and pale red, although a few gem-quality specimens were reported. Osterwald and others (1966) reported part of this deposit in sec. 18, T30N, R92W and noted that many of the crystals were largely altered to green mica.

Sec. 24, T30N, R93W. Red to purple corundum up to thumbnail size enclosed within dense green mica rims and hosted by mica schist have been mined from this location by George DeVault. A few star sapphires have been found, but most of the mined material has been cracked and is of poor quality.

Sec. 26, T30N, R96W. Mica schist surrounded by gray-brown granite contains pale blue sapphires and colorless corundum in rounded micaceous nodules up to 1 inch in diameter. These are located east of the U.S. Bureau of Land Management road between Highway 287 and Atlantic City (Hausel, 1986). Love (1970) reported that the sapphires and colorless corundum are abundant but badly fractured.

Medicine Bow Mountains.

Sec. 15, T15N, R83W. Specks of corundum have been identified in association with kyanite and sillimanite in a vermiculite deposit northeast of Encampment (Osterwald and others, 1966).

Laramie Mountains.

Sec. 18, T24N, R70W. The Roff vermiculite deposit in biotite schist contains accessory corundum and kyanite (Osterwald and others, 1966).

Tiny sapphires and rubies, approximately 1 mm or less in diameter, have been found in the Laramie Mountains during the course of the Geological Survey of Wyoming's search for kimberlite indicator-minerals in stream-sediments (Hausel and others, 1988). The sampling method used in this project eliminates most material larger than 1 mm sized, therefore, the potential for larger crystals has not been assessed. The following locations for corundum gems in the Laramie Mountains have been identified. Use of the term "possible" indicates a small degree of uncertainty in identification of a crystal due to its extremely small size:

NW SW sec. 29, T23N, R72W. Possible blue sapphire from the drainage entering the Laramie River from the north.

SW NE sec. 34, T23N, R73W. Three blue sapphires in the drainage entering the Laramie River from the east.

SW SE sec. 7, T22N, R72W. One dark blue sapphire in the drainage.

NW NE sec. 12, T22N, R73W. One blue sapphire in the drainage.

NW NW sec. 13, T22N, R73W. One possible blue sapphire in the drainage.

SW sec. 29, T19N, R71W. One ruby in the main eastward flowing drainage.

NW NE sec. 20, T14N, R71W. One possible ruby from Crow Creek.

Diamond

Diamond, made up entirely of carbon, is the only gemstone comprised of a single element. It is the hardest known naturally occurring mineral (hardness = 10), and its specific gravity is 3.5 to 3.53. Diamonds crystallize in the isometric system and usually are octahedral in form, although dodecahedrons, macles, twins, and irregular crystals are known (Hausel, 1986). Crystal faces often contain etched triangles or trigons. Diamonds have a perfect octahedral cleavage and a conchoidal fracture. They are brittle and can be easily broken. Diamonds will burn to carbon dioxide gas upon exposure to oxygen and high temperature, leaving no residue.

Diamonds are transparent to translucent with a brilliant adamantine to greasy luster and have a very high refractive index (2.42), which is responsible for the brilliancy of cut diamonds. Diamond colors range from colorless to pearly white, pale yellow, yellowish brown, pale brown, and black. Colors in pale shades of red, orange, green, and blue are also known (Hurlbut, 1966). Most diamonds are fluorescent to varying degrees. Diamonds are naturally nonwettable and grease attractive, so that diamonds adhere to grease and small stones will tend to float on water (Hausel, McCallum, and Roberts, 1985).

Diamonds are classified as either gem quality or industrial quality. Industrial-quality diamonds are frosted, contain numerous mineral inclusions, or are in some other way flawed to render them unsuitable as gemstones. Bort diamonds are microcystalline to granular, commonly in colors of gray, brown, or black, which are crushed and used as abrasive. Carbonado is black opaque bort made of diamond and amorphous carbon. Grit is sharp-edged diamond fragments.

Kimberlites and lamproites are the only rocks known to host commercial amounts of diamond. However, diamonds have been found in numerous other rock types, such as peridotite, which have origins associated with the Earth's mantle. Major diamond production from kimberlites worldwide comes from South Africa and the U.S.S.R., with lamproites supplying large quantities of diamonds from western Australia. The discovery of diamonds in the Colorado-Wyoming Kimberlite province in 1975 was only the second authenticated occurrence of diamonds found in place in North America (McCallum and Mabarak, 1976). The first such occurrence on this continent was near Murfreesboro, Arkansas in 1906 (Hurlbut, 1966). Diamond-bearing kimberlites have been found recently in Michigan and Canada.

Of the more than 100 known kimberlites in the Colorado-Wyoming kimberlite province, more than fifteen diamond-bearing kimberlite occurrences have been identified. Many of these kimberlites have not been adequately tested for the presence of diamonds. The Geological Survey of Wyoming's on-going stream-sediment sampling for heavy minerals indicative of kimberlites (pyrope garnet and chromian diopside) has identified dozens of anomalies in the Laramie Mountains (Hausel and others, 1988). The potential for the discovery of previously unknown kimberlites in Wyoming is high. Kimberlite indicator minerals have also been reported from the Cedar Mountain area in the southern Green River Basin (McCandless, 1982), but

these may be related to lamproite rather than kimberlite (Tom McCandless, personal communication to W. Dan Hausel, 1986). Lamproite flows and plugs are found north of Rock Springs in the Leucite Hills, but no diamonds are reported from this area.

All kimberlites so far identified in Wyoming intrude Proterozoic basement rocks south of the projected trend of the northeast-southwest trending Mullen Creek-Nash Fork shear zone, which separates the Proterozoic basement to the south from the Archean craton to the north. Craton-margin kimberlites and off-craton kimberlites of southern Africa are often barren of diamonds or poorly mineralized, whereas cratonic kimberlites host several commercial diamond deposits. The African analogy to the geology in southeastern Wyoming suggests that heavy-mineral anomalies north of the Mullen Creek-Nash Fork shear zone may indicate the presence of kimberlites hosting commercial diamond mineralization.

Diamonds were first reported from the vicinity of the Wyoming-Colorado border in 1871, when 80,000 carats of rubies and a 108-carat "diamond" reportedly from the Colorado-Wyoming area were displayed in a San Francisco bank. Soon afterward, a second exhibit of smaller stones in San Francisco succeeded in bringing financial support. An expedition to the discovery site in 1872 produced 1,000 carats of diamonds and more than 6,000 carats of rubies. Financial backing for development reached three-quarters of a million dollars. Investigations by the U.S. Geological Survey proved the discovery to be a hoax (King, undated). A small area on the Wyoming-Colorado border south of Rock Springs had been salted with a large quantity of rejected South African rough diamonds along with rubies, sapphires, emeralds, and by chance the kimberlite indicator mineral pyrope garnet (Lowell S. Hilpert, personal communication to W. Dan Hausel, 1983). The 108-carat stone in San Francisco turned out to be rock crystal (Bauer, 1968). The 1975 discovery of diamond occurred about 200 miles east of the 1872 diamond hoax.

Unverified reports began with a note about a diamond found in the gold placers along Beaver Creek near South Pass at the southern end of the Wind River Range (*The Fremont Clipper*, 1893). More recent reports include diamonds found along Bluegrass Creek in the central Laramie Mountains, the northern Laramie Mountains, the vicinity of Tourist Creek west of Gannett Peak in the Wind River Range, the Gros Ventre Mountains, Granite Mountains, Sierra Madre, southern Medicine Bow Mountains, and the vicinity of Lusk (Hausel, 1981, and personal communication, 1989). Another unverified report of diamonds in Wyoming identified microscopic diamonds extracted from a coal bed in the Powder River Basin (Finkelman and Brown, 1989).

Secs. 34 and 35, T17N, R81W. Two diamonds were found during the course of a gold placer operation along Cortex Creek in 1977 in the Medicine Bow Mountains by Paul Boden. One was a 3-mm average diameter stone of yellowish tint weighing 20.03 mg (0.1 carat), and the other was a 1.5-mm average diameter, clear octahedron weighing 6.94 mg (0.035 carat). Both diamond identifications were confirmed by x-ray diffraction at the Geological Survey of Wyoming (Hausel, 1977). No source for the diamonds was identified.

Secs. 5, 8, 16, and 21, T12N, R72W. Diamonds were discovered in the State Line kimberlite district in 1975. Approximately 40 kimberlite diatremes occur in the State Line District on both sides of the border. The diatremes range in size from dikes a few feet wide to almost 1,800 feet across (Hausel, McCallum, and Roberts, 1985). One dozen kimberlite occurrences identified on the Wyoming side of the border have been shown to contain diamonds.

Wyoming diamonds from the State Line District include both gem- and industrial-quality stones, with nearly 50 percent of the diamonds recovered being gem quality. The majority of the industrial-quality stones recovered here are the better grade used for cutting tools, with only a small amount classified as bort. The Wyoming gem-quality stones are generally clear with a high percentage of brilliant white colors. The largest diamond recovered from kimberlite on Wyoming State property was a clear gem weighing 0.86 carat (Hausel, 1986). The largest diamond from Colorado was a 2.5-carat industrial diamond (M.E. McCallum, personal communication to W. Dan Hausel, 1986).

Nephrite jade

Nephrite jade, the Wyoming State Gemstone, was first noted in Wyoming in 1936 with a discovery in the Granite Mountains in central Wyoming. Nephrite jade occurs as float over a wide area from around the southern end of the Wind River Range across central Wyoming as far north as Lysite, and east along the north side of the Laramie Mountains to the Platte River near Guernsey. Black Jade float has also been reported as far south as Sage Creek Basin near Rawlins (Ralph Platt, personal communication, 1989). The interest that began in 1936 continues to the present, although commercial mining is limited, with only six active jade-mining permits, according to the Wyoming Department of Environmental Quality. Wyoming jade remains in demand due to its reputation for good quality.

Nephrite jade is a member of the amphibole group of minerals, and is an intermediate species between black to green, iron-rich actinolite [$Ca_2(MgFe)_5Si_8O_{22}(OH)_2$] and white, magnesium-rich tremolite [$Ca_2Mg_5Si_8)_{22}(OH)_2$]. The habit is fibrous or massive prismatic, with a microscopic form of intricately interwoven fibers that give nephrite jade its extreme toughness and ability to resist fracture and cleavage. The more random and interlocking these fibers are the tougher the material. A gradation exists between extremely tough nephrite and actinolite-tremolite, which splits easily along the prominent amphibole cleavages.

Wyoming nephrite is opaque to translucent. Most commonly it is a medium to dark-green, but ranges in color from black to olive-green to light apple-green, gray, pink, and white. Its luster is waxy to vitreous, and its hardness is 5 to 6. The specific gravity of nephrite is 2.8 to 3.5, and its streak is white. The refractive index of nephrite ranges from 1.60 to 1.65.

Jadeite, a mineral of similar characteristics and uses in the pyroxene group of minerals is also commonly called jade, but is not known from Wyoming.

Nephrite is easily confused with similar appearing materials, and usually can only be positively identified by x-ray diffraction in combination with its physical characteristics. Rocks that are commonly confused with nephrite include epidote, serpentinite, fine-grained quartzite, and metadiabase. Hausel (1986) explained that these materials, which can occur in the same geologic settings as nephrite, can be distinguished by the numerous individual grains in the metadiabase, the perfect cleavage of epidote, the softness of serpentinite (H = 2.5), and the sparkle of a freshly broken surface combined with the granular texture of quartzite. Because of the similarities in appearance

between nephrite jade and some other minerals Root (1977) suggested the following rules for the field identification of nephrite jade:

1. Nephrite jade is heavier than the average rock of the same size.
2. Nephrite jade cannot be scratched with an ordinary knife blade.
3. Nephrite jade has a smooth, almost waxy appearance.
4. If the end is ground off of a potential piece of nephrite jade, the fresh surface should not sparkle or glitter in the sun. If it sparkles, it is not nephrite jade.

The quality of nephrite jade is based on its uniformity of texture and lack of inclusions. Most nephrite contains some inclusions, which may or may not effect its ability to take a polish (Sinkankas, 1959). In some material, small dark specks are common, which are softer than the nephrite and leave pits in the polished surfaces (Root, 1977). More nephrite is found of this inferior quality than of the uniform specimens. Nephrite colors generally vary within any given specimen, and inclusions or intermixings of other minerals may lead to names such as snowflake jade, which has a light mottled appearance. Colors are dependent on subtle differences in iron content in the mineral structure, with the lighter and brighter colors being rarer and more highly valued. Similarly, specimens that are more translucent are prized more highly than nearly opaque ones. The interrelationships of these combined attributes go into the overall assessment of quality of any particular nephrite jade specimen.

Detrital nephrite jade, or jade float, is found in Tertiary sediments and Quaternary gravels in a wide range of localities mostly centered on the Granite Mountains of central Wyoming. This detrital material, some of which has been reworked by erosional processes several times, has its origins in the Precambrian rocks of the nearby mountains. Love (1970) traced much of the geologic history of the jade deposits in central Wyoming. Nephrite jade boulders and cobbles ranging up to 3,000 pounds on the west end of Crooks Mountain have been found in the Crooks Gap Conglomerate, the Wasatch Formation, and the Battle Springs Formation. Nephrite jade boulders have also been found in the Ice Point Conglomerate and in the basal conglomerate of the White River Formation between the Granite Mountains and the southern end of the Wind River Range. Smaller pieces are found in the Wind River Formation north and west of the Granite Mountains, and small flakes of dark green jade up to 1 inch in diameter are found in the Split Rock Formation along with the Sweetwater agates. Emerald-green jade was found at one time in Quaternary lag gravels in the northeastern part of the Granite Mountains, and dark green jade has been found in pediment gravels on the north side of the Ferris and Seminoe Mountains and northeast of the Laramie Mountains.

Boulders, pebbles, and cobbles of nephrite jade have been extensively hunted for and picked up from the surface in most of the well-known jade areas for years, leaving mostly lower quality isolated materials. The effects of weathering expose a bit more jade each year, and although the chances of finding high-quality material are slight, it can happen, as shown by the discovery in the early 1970s of a 7-ton boulder of black jade in the Prospect Mountains, near the southern end of the Wind River Range (Hausel, 1986).

Individual pieces of jade vary greatly in appearance. Some pieces may be covered with a cream to reddish brown weathered rind, which effectively hides the true nature of the underlying jade. Such pieces usually require a corner to be chipped off before a proper identification can be made. Where the jade has been subjected to extensive water and wind erosion, the material

often takes on a natural high gloss polish that allows it to be easily recognized. These naturally polished pieces are commonly called jade "slicks".

Outcroppings of nephrite jade in place are much more limited than their detrital occurrences. It has been suggested that some of the sources for the high-quality apple-green and emerald-green jade have been buried deeply beneath late Tertiary and Quaternary deposits, and most likely will never be found. Known in-place nephrite deposits occur in Precambrian rocks associated with amphibolite inclusions in quartzofeldspathic gneiss in the Granite Mountains. Deposits in the Seminoe Mountains are associated with amphibolite dikes and inclusions, and deposits in the Laramie Mountains are found where quartz veins are emplaced in orthoamphibolite dikes (Sherer, 1969). According to Sherer (1969), these nephrite deposits were probably formed by metasomatic alteration of amphibolite at a temperature of 400° to 450° C and at a pressure of 4 to 5 kilobars. This alteration was concentrated along shear zones and fractures and resulted from the emplacement of quartz diorite, vein quartz, or pegmatite. Water loss at sites of nephrite development stopped the process of alteration. If alteration had continued, it would have converted the nephrite into serpentine.

Secs. 20 and 31, T31N, R85W. Emerald-green nephrite jade in Quaternary lag gravels has been found in these two sections and in other gravels to the northeast as far as the Grieve oil field in the center of T32N, R85W (Love, 1970). This area has been picked over thoroughly, since the emerald-green nephrite is some of the most prized material found in Wyoming. No in-place source for the emerald-green nephrite is known. The large area to the west and north to Dry Creek and the Rattlesnake Hills was popular for jade hunting during the late 1940s and early 1950s (Cheyenne Mineral and Gem Society, 1965).

T32N, R88W. Osterwald and others (1966) reported jade float to be found along Dry Creek in the Granite Mountains.

Ts30 and 31N, R90W. Small flakes of dark-green nephrite, generally less than 1 inch in diameter, are found in the Split Rock Formation along with the Sweetwater agates (Love, 1970).

Sec. 3, T29N, R90W. Jade veins were reported in this area by Harris and others (1985).

Sec. 20, T32N, R91W. Boulders of dark-green and black nephrite jade were reported by Love (1970) in the Wind River Formation.

Secs. 3, 16, 17, 18, 19, 20, 21, 29, and 30, T30N, R92W; and secs. 1, 2, 11, 13, and 24, T30N, R93W. Numerous in-place jade deposits are found in these sections associated with quartzofeldspathic gneiss (Sherer, 1969). These areas constitute the greatest concentration of in-place nephrite jade in Wyoming. The majority of these contain either black or dark-green nephrite; however, the Rhodes jade pit in SW SW sec. 3 contains thin apple-green nephrite dikes cutting granitic pegmatite and is one of the few localities where apple-green nephrite jade has been found in place (Love, 1970).

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

Secs. 29, 30, 31, and 32, T28N, R92W. Jade float was reported from the Crooks Gap area by Johnson (1973). According to Love (1970), apple-green nephrite jade boulders are present in the Crooks Gap Conglomerate, but they are not abundant.

Sec. 7, T28N, R93W. Apple-green nephrite jade boulders were found in this locality in the Wasatch and Battle Springs Formations, with a source area to the north in the Granite Mountains (Love, 1970).

Sec. 34, 29N, R95W. Love (1970) reported green and black nephrite jade boulders in the Ice Point Conglomerate at and around this location. At nearby Ice Point, boulders of excellent quality apple-green, pink, and black nephrite jade were once common before the thorough combing of the area by jade hunters. Even a small pebble of jade in this area is now a rarity.

T27N, R97W. This general area was reported by the Cheyenne Mineral and Gem Society (1965) to contain black jade float.

NW sec. 24, T29N, R97W. Love (1970) reported that an apple-green nephrite jade boulder was drilled through in a core hole at a depth of 400 feet in the basal conglomerate of the White River Formation.

Sec. 26, T30N, R96W. Gray nephrite jade was reported by Love (1970) in Precambrian aplite dikes.

T31N, R96W. Osterwald and others (1966) reported that jade float has been found along Beaver Creek near U.S. Highway 287.

Secs. 3, 4, 9, and 10, T29N, R103W; and secs. 27, 28, 33, and 34, T30N, R103W. Black nephrite jade was reported from this area north of the Prospect Mountains (Harris and others, 1985).

Secs. 30, 31, 35, and 36, T38N, Rs90 and 91W. This general area south of Lysite was reported by Rohn (1986) to contain black to dark green and gray-green nephrite jade float.

Sec. 23, T37N, R91W. According to Osterwald and others (1966), light green jade float has been found at Moneta.

Sec. 12, T26N, R84W. An elongate pod of top-quality black nephrite jade occurs in an epidote-monzonite inclusion in a small granite inlier at this location north of the Seminoe Mountains (Bishop, 1964).

T26N, Rs84 and 85W. Wind-faceted and angular boulders of both black and green nephrite jade are found in the pediment gravels north of the Seminoe Mountains. Many of these are covered by a red-brown alteration rind (Bishop, 1964).

Secs. 23 and 26, T26N, R85W. Nephrite jade in actinolite-amphibolite is found in place near the border between these two sections (Sherer, 1969).

Sec. 28, T26N, R85W. Bishop (1964) reported in-place jade in this section near the western end of the Seminoe Mountains.

Sec. 24, T29N, R84W. According to Osterwald and others (1966), jade has been reported from the Pathfinder Dam area.

T21N, R87W. Osterwald and others (1966) reported that nephrite float had been found on the Rawlins golf course.

Ts18 and 19N, Rs86 and 87W. Ralph Platt (personal communication, 1989) related that good-quality black jade float was found in the Sage Creek basin south of Rawlins.

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

Secs. 5, 6, and 19, T29N, R74W; sec. 13, T29N, R75W; and sec. 32, T30N, R74W. Sherer (1969) reported several nephrite jade deposits associated with orthoamphibolite dikes in these sections in the northern part of the Laramie Mountains. Several townships northeast of this area near the Platte River were identified by Keenan (1964) as potentially containing alluvial jade.

Secs. 19, 29, and 30, T32N, R73W; and secs. 24 and 25, T32N, R74W. This area west of LaPrele Reservoir was reported by Bob Berry (personal communication, 1988) to contain in-place nephrite jade deposits.

Secs. 5, 6, 7, and 8, T30N, R68W. The Eloxinite Corporation (1971) reported jade slicks in this area near Glendo Reservoir. Similar occurrences are also reported along the northern shore of Glendo Reservoir.

NE SE sec. 6, T26N, R65W. A piece of dark green to black nephrite jade was reported by R.E. Harris (personal communication, 1988) from a gravel pit southeast of Guernsey.

Opal

Opal is a macroscopically amorphous hydrous silicon dioxide ($SiO_2 \cdot nH_2O$). Water content varies up to 10 percent, and luster varies from glassy to resinous and occasionally pearly. The hardness of opal is 5.5 to 6.5, and it is extremely brittle with a conchoidal fracture. Abrupt changes in temperature can cause opal to fracture, and excessive heat or dryness can drive off water and destroy some specimens of precious opal. According to Sinkankas (1959) opal's specific gravity varies from 1.9 to 2.2, and its refractive index is from 1.444 to 1.464, showing only a single refraction with no dichroism, even in strongly colored specimens. Opal can be anywhere between poorly translucent to almost transparent. Its colors are highly variable, from colorless to white, cream, yellow, orange, red, brown, and black, with pastels being the most common. Pinks and greens are also known. Opal is precipitated from silica-rich waters as fissure and void fillings (particularly in association with volcanic rocks). It is found as deposits associated with geysers and hot springs and it also occurs as a replacement in wood (opalized wood). Its form in these situations ranges from botryoidal to stalactitic to veins and seams. Opal also appears to be associated with Tertiary tuffaceous material and is reported from the White River and Wind River formations. These occurrences seem to be

analogous to some chalcedony development. Opal can be distinguished from chalcedony by the combination of its lower specific gravity, its distinctive luster, its more prominent conchoidal fracture, and its lesser hardness.

Sinkankas (1959) cited the name "opal" as originating in the Sanskrit "upala", meaning "precious stone", which was changed by the Greeks and Romans to "opalus", from which we get opal. Opal is brittle, easily scratched, and sensitive to heat, but it earns its place as a gemstone from the play of intense colors found in precious opal. The color displays, usually in blues, reds, and yellows, are found only in precious opal and result from a microscopic ordering of its internal structure, which is not observed in the poorly translucent common opal. Fire opal is a bright red to yellow translucent opal showing a play of colors. Other terms used to describe opal include color (such as white or black), inclusions similar to those found in agates (moss opal), and replacement of materials such as opalized wood. Silicious sinter or geyserite is a variety of common opal that forms terraces and cones around some geysers such as in Yellowstone National Park (Sinkankas, 1959). Opal also forms the skeletons of some tiny sea animals, such as diatoms and radiolaria, resulting in some ocean floor sediments being made up almost entirely of opal.

Opal is not common in Wyoming, but it is found in association with the Yellowstone and Absaroka volcanics and has been reported from some tuffaceous Tertiary deposits such as the Oligocene White River Formation along the Beaver Divide (Love, 1989). Sinkankas (1959) described common opal found in Yellowstone Park at several localities, including Specimen Ridge and Amethyst Mountain. Seams of opal occur on the north flank of Mount Washburn, and opalized wood is found in several areas of Yellowstone's petrified forest. **No collecting of any kind is allowed in Yellowstone National Park.** J.D. Love (personal communication, 1989) reported that some specimens of fire opal have been found in the Absaroka Mountains, and common opal was reported from the White River Formation in the northern part of the Hartville uplift (Mueller, 1976). White opal was at one time found in quantity near Pathfinder Reservoir in central Wyoming (Ralph Platt, personal communication, 1989). Osterwald and others (1966) related several reports of opal in the Granite Mountains area along the Sweetwater River, Sage Hen Creek, at Agate Lake, and near Jackson Lake in northwestern Wyoming. Common opal was also reported by Ralph Platt (personal communication, 1989) from the vicinity of Cyclone Ridge in southern Wyoming.

Sec. 16, T42N, R60W. Gruner and others (1956) mentioned opal in association with uranium mineralization in the Lower Cretaceous Fall River Formation in this section. This may have been on or near the Wicker-Baldwin property.

Sec. 28, T32N, R69W. This section was reported by Gruner (1955) and Gruner and others (1956) to contain opal, quartz, and chalcedony in tuffaceous silty sediments of the Oligocene White River Formation in conjunction with a series of northeast-southwest 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.

NW sec. 2, T21N, R85W. Osterwald and others (1966) reported opal (?) along the northern edge of a shear zone in contact with red quartz monzonite along with an associated pod of barite.

Sec. 26, T33N, R90W. Opal with a trace of uranium was reported by Gruner and others (1956) from the Vitro Uranium Co. pit in the middle to upper Eocene Wind River Formation in the Gas Hills area.

Sec. 23, T33N, R90W. Gruner and others (1956) mentioned opal "sulfogel" associated with uranium mineralization on the Lucky Mac property.

Sec. 32, T27N, R84W. Clear moss opal and white common opal were reported by Bohn Dunbar (personal communication, 1989) from the center of this section on the west side of Pathfinder Reservoir. This deposit appears to occur in white tuffaceous sandstone of the Miocene Split Rock (?) Formation. Common white opal is also reported from the same sedimentary unit east of Pathfinder Reservoir.

T22N, Rs112 and 113W. Opal Bench extends east-west across the bottom edge of these townships. Quaternary sand on top of the Bridger Formation makes up the bench. The source of the name is not known.

NE sec. 21, T21N, R114W. Opal Springs is underlain by the Laney Shale Member of the Green River Formation. The place name, "Opal", is also found in sec. 26 of this township. The source of these place names is not known.

Quartz (coarsely crystalline)

Quartz (SiO_2) is the most common rock-forming mineral on the Earth's surface. It occurs as both microcrystalline quartz (chalcedony) and in more coarsely crystalline forms. Quartz is a significant component of many types of igneous, metamorphic, and sedimentary rocks, and it is almost the only mineral in some quartzites and sandstones. Quartz has a hardness of 7 and a specific gravity of 2.65. It has a vitreous luster, a conchoidal fracture, and crystallizes in the hexagonal system. Coarsely crystalline quartz often occurs as hexagonal prisms with faces horizontally striated, capped by a six-sided pyramid.

Coarsely crystalline quartz is usually colorless (rock crystal) or white (milky quartz), but may be any color due to various impurities. Other colors include purple (amethyst), possibly due to small amounts of ferric iron; rose-red to pink (rose quartz), colored by traces of titanium; smoky yellow to brown and black (smoky quartz), colored by exposure to radiation from radioactive decay; and pale yellow to reddish brown quartz called citrine (Hurlbut, 1966). Quartz crystals with brown to red inclusions are called ferruginous quartz. The inclusion of rutile needles within the crystals results is called rutilated quartz. Bull quartz is a white, coarse-grained, massive quartz essentially free of any accessory minerals. Drusy quartz is a layer or coating of tiny quartz crystals lining a cavity or covering a surface.

Aspects of quartz such as its piezoelectric and pyroelectric properties and the left or right-handedness of crystals and types of twinning have in recent years become important to the "New Age" crystal fad. Such properties have been used by the electronics industry for years, and were the impetus for the development of synthetic quartz crystals during World War II. Piezoelectricity is the development of a surface electric charge on a crystal when it is strained to cause an elastic deformation; pyroelectricity is the similar development of a charge when a crystal undergoes an appropriate

temperature change. The handedness in a quartz crystal relates to the internal stacking arrangement of the silica tetrahedrons that make up the crystal. For details concerning crystal structure, symmetry, and twinning, the reader is referred to a good mineralogy text such as *Dana's manual of mineralogy* (Hurlbut, 1966). The current "New Age" interest in naturally occurring quartz crystals has resulted in relatively high prices for quartz crystals. Comparably high prices were last seen before synthetic quartz replaced naturally occurring quartz in electronics applications.

Coarse quartz crystals are found in granites and pegmatites, and quartz deposited from solutions is the most common material in veins and fracture fillings. Quartz crystals are also found associated with chalcedony nodules as void fillings (geodes) and in voids in petrified wood.

Quartz crystals are found in many areas of Wyoming in igneous and metamorphic rocks, in pegmatites and veins, and in association with various types of chalcedony. These include rock crystal, milky quartz, rose quartz, ferruginous quartz, and amethyst. Small clear crystals, inappropriately called "Wyoming diamonds" were at one time common in the Sweetwater agate beds and in the Blue Forest petrified wood area (see Chalcedony). Milky quartz is found in veins in most of Wyoming's Precambrian-cored mountain ranges. Amethyst is found in the Sierra Madre Mountains, the Laramie Mountains, and the Black Hills, and in association with petrified wood in the Powder River Basin and in Yellowstone National Park.

Sec. 2, T12N, R72W. Well-formed iron-stained quartz crystals are found in Precambrian pegmatites along U.S. Highway 287 south of Tie Siding in the southwest quarter of this section (Hausel, 1986). Other pegmatites in this general area are reported to yield similar material.

Secs. 4, 5, and 6, T23N, R71W; and secs. 35 and 36, T24N, R72W. Tiny amethyst crystals (less than 1 mm) were found during the course of a stream-sediment sampling program, which included Duck Creek in these sections. The nature of the sampling precluded recovery of any larger material, however these small crystals suggest the possibility that larger crystals may be found.

Sec. 19, T23N, R69W. Massive white bull quartz is found in several pod-like veins in the east half of this section. Individual crystals are rare. The piezoelectric properties of this material are well developed and it gives off a noticeable electric spark when struck. Some rose quartz is also present, but with a less well-developed piezoelectric display (R.E. Harris, personal communication, 1989).

Secs. 5 and 8, T14N, R77W; and secs. 20, 29, and 32, T15N, R77W. Large log-like concretions, which weather out of the Jurassic Sundance Formation on the west side of Sheep Mountain, were reported by Osterwald and others (1966) to contain small amounts of low-quality amethyst.

Sec. 31, T17N, R78W. Clear quartz crystals up to 1 1/2 inches long by 1/2 inches thick have been found as isolated float in this section.

Sec. 2, T13N, R86W; and sec. 35, T14N, R86W. Platt (1947) reported that amethyst crystals and other colored quartz including black, smoky, rose, milky white, and clear are found south of Battle Lake. The crystals occur in geodes as well as in flat coatings in cracks in red granite. Most of these crystals are small, less than 2 inches in length.

NE SW sec. 11, T15N, R87W. Clear to milky quartz crystals up to 3/8 inch long are found in a quartz vein near the Gold Coin mine.

Secs. 6 and 7, T32N, R74W; and secs. 1 and 12, T32N, R75W. Small quartz crystals set in chalcedony within geodes are reported in sandstones in Box Elder Canyon (Osterwald and others, 1966).

Secs. 17, 18, 19, and 20, T32N, R79W. Smoky quartz occurs in pink pegmatite dikes intruding the Precambrian core of Casper Mountain (Harris and Hausel, 1986).

T32N, R69W. Silicified fault zones in the southern half of this township form discontinuous sharp ridges up to 30 feet wide. These ridges contain some quartz crystals along with chalcedony and some opal (Gruner, 1955).

Sec. 32, T51N, R60W. Amethyst crystals up to 1 inch or more in length were found by W. Dan Hausel (personal communication, 1989) at the Arctic II Mine in the north central part of this section. Groups of amethyst crystals, usually with an opaque coating, were found in pyroxenite along with purple chalcedony and drusy quartz.

T51N, Rs80 and 81W. Amethyst-lined cavities were reported by Zeitner (1966) to be found in some specimens of petrified wood in this area (see chalcedony).

Ts30 and 31N, R90W. Small clear quartz crystals were at one time relatively common in the Sweetwater agate beds. These crystals were referred to as "Wyoming diamonds" because of their clarity, small size, and symmetrical shape.

T29N, R100W. Clear to milky and ferruginous quartz crystals are found in quartz veins in the South Pass-Atlantic City gold mining district.

Secs. 28, 29, 30, 31, 32, and 33, T24N, R110W. Small, clear, symmetrical quartz crystals were common in the Blue Forest area before excessive collecting took place. Like crystals found in the Sweetwater agate beds, these were also termed "Wyoming diamonds".

T56N, R111W. Amethyst and rock crystal fill the voids in some petrified wood and wood casts in the vicinity of Amethyst Mountain in Yellowstone Park. **No collecting of any kind is allowed within the boundaries of the National Park without a special research permit.** These quartz crystals are found over a wide area, and are responsible for the name of Amethyst Mountain (Sinkankas, 1959).

Rocks

Several more or less common rock types can be included in the classification of lapidary materials by virtue of their use in cut and polished forms for ornamental objects. Some of these rocks may also be used by the construction industry for purposes related to their appearance. These rock types need only to be durable and free of excessive fractures and to have a pleasing appearance after cutting and polishing. Rock types considered for

lapidary use include granite and other igneous intrusives, gneiss, quartzite, marble, and limestone. Only the more unique types are listed here.

Center N 1/2 SW sec. 30, T27N, R87W. Orbicular granodiorite was reported from the Ferris Mountains by Master (1977). The quartz diorite orbicules in a granodiorite porphyry groundmass make up one of the most visually interesting rocks in Wyoming.

T56N, R88W. "Leopard rock" is a local term used to describe a unique mafic dike rock intruding Precambrian quartz monzonite in the Bighorn Mountains northeast of Burgess Junction (Manzer and Heimlich, 1974). The porphyritic gabbro dikes, at various localities within the area, exhibit crowded phenocrysts of altered plagioclase feldspar (labradorite-bytownite) 5 to 8 cm across, which give the rock a black and white spotted or leopard appearance. This rock has seen limited use as a decorative stone.

Sec. 7, T40N, R92W. Green fuchsitic quartzite (quartzite containing fuchsite, a green chromium mica) crops out in the south half of this section in a northeast-southwest trending quartzite band that extends for several miles in both directions. This material is also referred to as aventurine.

Sec. 36, T23N, R71W. Dark green fuchsitic quartzite in a narrow band about 8 feet wide extends for about 3/4 mile across this section in the Laramie Mountains (R.E. Harris, personal communication, 1989).

Secs. 8 and 9, T16N, R79W. Light green fuchsitic quartzite was at one time quarried from this locality in the Medicine Bow Mountains.

SE sec. 20, T26N, R85W. During mapping of the Seminoe Mountains, a spectacular plug of leopard rock was found here (W.D. Hausel, personal communication, 1990).

Sec. 15, T28N, R98W. "Spotted basalt" similar to leopard rock was found by W.D. Hausel (personal communication, 1989) in the Roundtop Mountain Greenstone while mapping the South Pass region. The basalt consists of large (1 inch) white xenocrysts of clinozoisite after feldspar in a black aphanitic matrix.

Selenite

Selenite ($CaSO_4 \cdot H_2O$) is crystalline gypsum, which is commonly found throughout Wyoming as isolated crystals in Tertiary or Cretaceous shales. Selenite crystals are transparent colorless to white, vitreous, prismatic or tabular gypsum crystals. Selenite, which sometimes forms "fishtail" twin crystals, occurs in the monoclinic crystal system. It's specific gravity is 2.32 and its hardness is 2. Scattered selenite crystals found on the ground surface give a sparkling appearance in the sunlight to some outcrops of dark carbonaceous shales across Wyoming and many parts of the arid west. These interesting collectables, which have occasionally been erroneously termed "Wyoming diamonds", range in size up to several inches across and are particularly noted on outcrops of the Lower Cretaceous Thermopolis Shale. Other formations that commonly exhibit selenite crystals include the Upper Cretaceous Cody, Niobrara, and Steele shales as well as carbonaceous shales

within the Paleocene Fort Union and Eocene Wasatch formations. Be sure to check out the Geologic map of Wyoming (Love and Christiansen, 1985) for the appropriate outcrop nearest you.

Sec. 20, T40N, R79W. Selenite crystals up to 3 inches long are associated with bentonite in the Steele Shale in this section and in the surrounding area (Osterwald and others, 1966).

Secs. 3 and 4, T36N, R83W. Selenite crystals in the Steele Shale are abundant in the north half of these sections (Osterwald and others, 1966).

Tourmaline

Tourmaline is a complex aluminum silicate containing variable amounts of magnesium, sodium, potassium, and water. It may also contain fluorine, iron, lithium, manganese, and other elements. Large amounts of iron may cause tourmaline to be black and nearly opaque rendering it unsuitable as a gemstone (Bauer, 1968). Tourmaline belongs to the hexagonal crystal system and forms elongate crystals with a rounded triangular cross section. Striations are common parallel to the long axis of the crystals and basal fractures are perpendicular to the striations. Tourmaline has a hardness of 7 to 7.5 and a specific gravity of 3.03 to 3.25.

Tourmaline has a vitreous luster and is predominantly black (called schorl) and occasionally green. Gem varieties are translucent to transparent in pale colors including pink, red, violet, blue, green, yellow, and brown. No gem varieties of tourmaline have been reported from Wyoming, however large well-formed black or green specimens are interesting collectables.

Hartville uplift

Sec. 1, T27N, R65W. Black tourmaline is abundant in a pegmatite exposed in the Haystack No. 1 prospect (Hanley and others, 1950).

Sec. 35, T28N, R65W. The Chicago prospect in SW NE and SE NW of this section contains black tourmaline in the border zone of a poorly zoned pegmatite. Similar tourmaline is found in the Ruth prospect about 600 feet to the south (Hanley and others, 1950).

T28N, R65W. The Crystal Palace prospect is centered on the line between secs. 34 and 35 and in the NE and NW of the sections respectively. An indistinctly zoned pegmatite 10 feet wide cuts the Precambrian Whelen schists and gneisses in a 70-foot-long exposure. The pegmatite contains a wall zone rich in muscovite with black tourmaline as an accessory mineral and a large quantity of black tourmaline at the wall rock contact (Hanley and others, 1950).

Sec. 35, T28N, R65W. The Torrington No. 1 prospect about 1,450 feet northeast of the Crystal Palace contains black tourmaline throughout the pegmatite (Hanley and others, 1950).

NE NW and NW NE sec. 35, T28N, R65W. The New York prospect pegmatite, up to 35 feet wide, is well zoned with the outer 1 to 2 feet of the mica-bearing zone of

the dike being rich in black tourmaline. Some of these tourmaline crystals are as large as 8 inches in diameter (Hanley and others, 1950).

Laramie Mountains

Sec. 11, T24N, R71W. Deep pink translucent tourmaline crystals less than 1 mm in size are found in the south-central part of this section along Lumen Creek. These tourmaline crystals were identified during the Geological Survey of Wyoming's stream-sediment sampling program in search of kimberlite intrusives. Sampling procedures limited the material size recovered to less than 0.04 inches (Hausel and others, 1988).

Medicine Bow Mountains and Sierra Madre

Sec. 32, T13N, R78W. Beckwith (1937) reported black tourmaline crystals up to several inches long are found in metadiabase and hornblende schist adjacent to pegmatite dikes on the Muscovite and Ione mining claims in the SE1/4 and SW1/4 of this section respectively. Fine-grained black tourmaline also occurs as matted fibers within the pegmatite dike.

Ts13 and 14N, Rs8 and 79W. Harris and Hausel (1986) reported tourmaline as an accessory mineral in pegmatites in the Big Creek district in the Medicine Bow Mountains southeast of Encampment.

Sec. 20, T14N, R83W. Osterwald and others (1966) reported light green tourmaline (?), muscovite, and kyanite from a pegmatite on the Big Chief Nos. 1 and 2 claims in this section.

Casper Mountain:

Secs. 16, 17, 18, 19, and 20, T32N, R79W. Schorl was reported from pegmatites in the Precambrian core of Casper Mountain (Beckwith, 1939).

Granite Mountains:

SE sec. 36, T33N, R89W. The Black Mountain pegmatite is made up of coarsely crystalline potash feldspar and white quartz with green and black tourmaline as an accessory mineral (Love, 1942).

Wind River Range:

Ts28 and 29N, Rs101 and 102W. Several of the pegmatites that cut the area surrounding Anderson Ridge at the southern end of the Wind River Range contain tourmaline. Tourmaline pegmatites are mainly present in the central part of the Anderson Ridge Quadrangle and in a zone extending to the northeast. Tourmaline-bearing pegmatite is also present in the southern part of secs. 23 and 24, T29N, R102W Visible tourmaline decreases in abundance outside these zones. The individual crystals vary from a few millimeters up to 20 cm in length and 6 cm in diameter. The larger crystals are euhedral to subhedral and exhibit the characteristic triangular cross section. All crystals appear to be black schorl. They are generally fractured and cracked (El-Etr, 1963).

NE sec. 24, T29N, R101W. Pegmatite granite and pegmatite cutting metagreywacke contain black tourmaline (Hausel, 1986). Bayley (1965b) reported that one pegmatite contains a thin central zone of blue tourmaline, spodumene, and lepidolite.

Topaz

Topaz [$Al_2(SiO_4)(F, OH)_2$] is well known as a yellow gemstone, although other colors occur. It is known by many students of geology for its hardness of 8 on Mohs hardness scale. Topaz crystals are orthorhombic, usually with a combination of prisms forming elongated eight-sided columns terminated by pyramids or prisms. Striations parallel to the long axis are common, and a perfect basal cleavage perpendicular to its long axis is produced when crystals are removed from a cavity (Bauer, 1968). Topaz has a high specific gravity (3.4 - 3.6). It is pyroelectric, acquiring an electric charge when heated and releasing the charge after cooling. Topaz also acquires an electric charge when rubbed (similar to amber). The luster of topaz is vitreous, and its color ranges from colorless to yellow to pink, blue, and blue-green. Only clear transparent stones are considered for use as gemstones, with the darker colors being more desirable (Bauer, 1968). Topaz is formed from fluorine-bearing vapors during late-stage crystallization of igneous rocks. It is found in cavities in rhyolite lavas and granite and in pegmatites, particularly those bearing tin (Hurlbut, 1966).

The only locality from which topaz has been reported in Wyoming is the Mineral Hill area in the Black Hills (T51N, R60W). Irving and Emmons (1904) described "minute crystals of topaz" and cassiterite in some of the gulch placers surrounding Mineral Hill.

Zircon

Zircon $Zr(SiO_4)$ is considered a semiprecious stone only when it is transparent. Zircon has a specific gravity of 4.68, and a hardness of 7.5. It belongs to the tetragonal crystal system, and its crystals usually form a simple combination of a rectangular prism and a dipyramid. Its color is usually brown or red, but may be yellow or colorless. The transparent color range between red and yellow in zircon is called hyacinth (Bauer, 1968). The luster of zircon is adamantine and, in combination with its high refractive index (1.92 - 1.97), results in some usage as imitation diamonds. Zircon is found as an accessory mineral in all types of igneous rocks, particularly in the more silicious rocks such as granite, granodiorite, syenite, and monzonite (Hurlbut, 1966). Due to their resistance to weathering, zircon crystals used as gems are usually found in detrital material rather than derived from solid unweathered rock. Small zircon crystals are found in Precambrian rocks in the cores of many of Wyoming's mountain ranges.

Secs. 23, 24, 25, 26, 27, 35, and 36, T58N, R92W. Pegmatites in the Cookstove Basin area in the northern Bighorn Mountains contain zircon as an accessory mineral.

References cited

Aldrich, R., 1973, Eden Valley Wood: Earth Sciences, January-February, p. 40-43.

Bauer, Max, 1968, Precious stones: Dover Publications, New York, 627 p.

Bayley, R.W., 1965a, Geologic map of the Miners Delight Quadrangle, Wyoming: U.S. Geological Survey Geologic Quadrangle Map GQ-460, scale 1:24,000.

Bayley, R.W., 1965b, Geologic map of the South Pass City Quadrangle, Fremont County, Wyoming: U.S. Geological Survey Geologic Quardangle Map GQ-458, scale 1:24,000.

Beckwith, R.H., 1937, The geology of the Muscovite and Ione mining claims: Geological Survey of Wyoming Mineral Report 37-1 (unpublished), 5 p.

Beckwith, R.H., 1939, Asbestos and chromite deposits of Wyoming: Economic Geology, v. 34, no. 7, p. 812-843.

Bishop, D.T., 1964, Retrogressive metamorphism in the Seminoe Mountains, Carbon County, Wyoming: M.S. thesis, University of Wyoming, Laramie, p. 43-47.

Bradley, W.H., 1964, Geology of the Green River Formation and associated Eocene rocks in southwestern Wyoming and adjacent parts of Colorado and Utah: U.S. Geological Survey Professional Paper 496-1, 86 p.

Breithaupt, Brent, 1983, *Goniobasis* agate: Rocks and Minerals Magazine, September-October, p. 247.

Breitweiser, W.R., 1966, A beautiful Wyoming agate, *in* The agates of North America, Hugh Leiper, editor: The Lapidary Journal, p. 63.

Brownlow, A.H., and Komorowski, Jean-Christophe, 1988, Geology and origin of the Yogo sapphire deposit, Montana: Economic Geology, v. 83, no. 4, p. 875-880.

Cheyenne Mineral and Gem Society, 1965, The Wyoming rockhunter's guide: Cheyenne, Wyoming, 29 p.

Deer, W.A., Howie, R.A., and Zussman, J., 1966, An introduction to the rock forming minerals: John Wiley and Sons, New York, 528 p.

Durkin, T.V., 1986, A palynological study of the Petrified Forest area of the early Eocene Wasatch deposits near Buffalo, Wyoming: M.S. thesis, South Dakota School of Mines and Technology, Rapid City, 271 p.

El-Etr, H.A., 1963, Pegmatites of the Anderson Ridge Quadrangle, Fremont County, Wyoming: M.S. thesis, University of Missouri at Rolla, 102 p.

Eloxite Corporation, 1971, Revised Wyoming collecting localities and latest collecting information: Eloxite Corporation, Wheatland, Wyoming, 35 p.

Elwood, M.W., 1978, Geology of the Black Buttes, Crook County, Wyoming: M.S. thesis, South Dakota School of Mines and Technology, Rapid City, 123 p.

Finkelman, R.B., and Brown, R.D., Jr., 1989, Mineral resource and geochemical exploration potential of coal that has anomalous metal concentrations, *in* U.S. Geological Survey Research on Mineral Resources-1989, Katharine S. Schindler, editor: U.S. Geological Survey Circular 1035, p. 18-19.

(The) Fremont Clipper, 1893, Precious stones: Fremont Clipper, v. VII, no. 17 (unpaginated).

Gems & Minerals Magazine, 1973, News and notes of collecting areas--Wyoming: Gems & Minerals Magazine, no. 433, p. 14.

Glass, G.B., 1975, Analyses and measured sections of 54 Wyoming coal samples: Geological Survey of Wyoming Report of Investigations 11, 219 p.

Gems & Minerals Magazine, 1976, News and notes of collecting areas--Wyoming: Gems & Minerals Magazine, no. 465, p. 34.

Gruner, J.W., 1955, Field notes: University of Minnesota (unpublished).

Gruner, J.W., Smith, D.K., Jr., and Knox, J.A., 1956, U.S. Atomic Energy Commission Annual Report for April 1, 1955 to March 31, 1956, Part II, RME-3137: University of Minnesota, Minneapolis, 27 p.

Guilinger, R.R., 1956, Geologic studies with results of airborne reconnaissance in the Shawnee-Lance Creek districts, Converse and Niobrara Counties, Wyoming: Report to the U.S. Atomic Energy Commission, TMD1-13, 33 p.

Hanley, J.B., Heinrich, E.W., and Page, L.R., 1950, Pegmatite investigations in Colorado, Utah, and Wyoming: U.S. Geological Survey Professional Paper 227, p. 107-121.

Harris, R.E., and Hausel, W.D., 1986, Wyoming pegmatites, *in* Colorado pegmatites, P.J. Modreski, editor: Colorado Chapter Friends of Mineralogy, Denver, p. 101-108.

Harris, R.E., Hausel, W.D., Meyer, J.E., 1985, Metallic and industrial minerals map of Wyoming: Geological Survey of Wyoming Map Series 14, scale 1:500,000.

Hausel, W.D., 1977, Boden diamonds notes: Geological Survey of Wyoming Mineral Report 77-1 (unpublished), 9 p.

Hausel, W.D., 1981, Notes on diamond discussions with Dr. J.D. Love (U.S. Geological Survey) and with Dr. Ron Marrs (Geology Department, University of Wyoming): Geological Survey of Wyoming files (unpublished), 3 p.

Hausel, W.D., 1986, Minerals and rocks of Wyoming: Geological Survey of Wyoming Bulletin No. 66, 117 p.

Hausel, W.D., 1989, The geology of Wyoming's precious metal lode and placer deposits: Geological Survey of Wyoming Bulletin 68, 248 p.

Hausel, W.D., Glahn, P.R., and Woodzick, T.L., 1981, Geological and geophysical investigations of kimberlite in the Laramie Range of southeastern Wyoming: Geological Survey of Wyoming Preliminary Report No. 18, 13 p.

Hausel, W.D., and Glass, G.B., 1980, Minerals and coal--Natrona County: Geological Survey of Wyoming County Resource Series 6, scale 1:500,000.

Hausel, W.D., Graff, P.J., and Albert, K.G., 1985, Economic geology of the Copper Mountain supracrustal belt, Owl Creek Mountains, Fremont County, Wyoming: Geological Survey of Wyoming Report of Investigations No. 28, 33 p.

Hausel, W.D., Harris, R.E., King, J.K., and Sutherland, W.M., 1990, Metallic and radioactive minerals and lapidary materials map of the Powder River Basin and adjacent uplifts, Wyoming: Geological Survey of Wyoming Map Series 32, scale 1:500,000.

Hausel, W.D., McCallum, M.E., and Roberts, J.T., 1985, The geology, diamond testing procedures, and economic potential of the Colorado-Wyoming kimberlite province--a review: Geological Survey of Wyoming Report of Investigations No. 31, 22 p.

Hausel, W.D., Sutherland, W.M., and Gregory, E.B., 1988, Stream-sediment sample results in search of kimberlite intrusives in southeastern Wyoming: Geological Survey of Wyoming Open File Report 88-11, 11 p.

Hayford, J., 1971, Rockhounding in southeast Wyoming, *in* Pik-N-Rok: Bulletin of the Red Valley Gem and Mineral Club, Grand Forks, North Dakota, 7 p.

Hurlbut, C.S., Jr., 1966, Dana's manual of mineralogy, seventeenth edition: John Wiley and Sons, New York, 609 p.

Irving, J.D., and Emmons, S.F., 1904, Economic resources of the northern Black Hills, part II, mining geology: U.S. Geological Survey Professional Paper 26, p. 53-222.

Johnson, C., 1973, Western gem hunters atlas: Cy Johnson and Son, Susanville, California, 79 P.

Jones, R.W., 1990, Coal update: Geological Survey of Wyoming, Wyoming Geonotes No. 27, p. 44.

Jones, R.W., in press, Coal map of Wyoming: Geological Survey of Wyoming Map Series 34, scale 1:500,000.

Keenan, J.E., 1964, Common gemstones of Wyoming, *in* Highway geology of Wyoming: Wyoming Geological Association, p. 9-11.

King, Clarence, undated, The diamond discovery of 1872, *in* Records of the U.S. Geological Survey, Geologists Field Notebooks No. 1113: National Archives Record Group No. 57, 19 p.

Love, J.D., 1942, Memorandum on Black Mountain spodumene deposit, Black Mountain, Natrona County, Wyoming: Geological Survey of Wyoming Mineral Report 42-46 (unpublished), 1 p.

Love, J.D., 1970, Cenozoic geology of the Granite Mountains area, central Wyoming: U.S. Geological Survey Professional Paper 495-C, 154 p.

Love, J.D., and Christiansen, A.C., 1985, Geologic map of Wyoming: U.S. Geological Survey, scale 1:500,000.

Lovering, T.G., 1972, Jasperoid in the United States--its characteristics, origin, and economic significance: U.S. Geological Survey Professional Paper 710, 164 p.

Madson, M.E., 1983, Radioactive turtle shells: Rocks and Minerals Magazine, September-October, p. 245-246.

Manzer, G.K., Jr., and Heimlich, R.A., 1974, Petrology of mafic and ultramafic rocks from the northern Bighorn Mountains, Wyoming: Geological Society of America Bulletin, v. 85, no. 5, p. 703-708.

Mapel, W.J., 1959, Geology and coal resources of the Buffalo-Lake De Smet area, Johnson and Sheridan Counties, Wyoming: U.S. Geological Survey Bulletin 1078, p. 46-49.

Master, Tim, 1977, Rock and mineral occurrences in the Ferris Mountains, Wyoming: M.S. thesis, University of Wyoming, Laramie, Wyoming, 147 p.

McCallum, M.E., and Mabarak, C.D., 1976, Diamond in State-Line kimberlite diatremes, Albany County, Wyoming, Larimer County, Colorado: Geological Survey of Wyoming Report of Investigations No. 12, 36 p.

McCallum, M.E., and Orback, C.J., 1968, The New Rambler copper-gold-platinum district, Albany and Carbon Counties, Wyoming: Geological Survey of Wyoming Preliminary Report No. 8, 12 p.

McCandless, T.E., 1982, The mineralogy, morphology, and chemistry of detrital minerals of a kimberlitic and eclogitic nature, Green River Basin, Wyoming: M.S. thesis, University of Utah. Salt Lake City, 107 p.

McLaughlin, T.G., 1940, Pegmatite dikes of the Bridger Mountains, Wyoming: American Mineralogist, v. 25, p. 46-68.

Millgate, M.L., 1965, The Haystack Range, Goshen and Platte Counties: Geological Survey of Wyoming Preliminary Report No. 5, p. 8.

Mitchell, J.R., 1982, Fontenelle agate and wood: Rock and Gem Magazine, September, p. 48-51.

Mitchell, J.R., 1984, Cedar Mountain agate: Rock and Gem Magazine, November, p. 64-67.

Mueller, J.W., 1976, Geology and ore controls of uranium deposits in Oligocene and Miocene sediments, northern Hartville uplift, Wyoming: Colorado School of Mines, Golden, 119 p.

Mustoe, G.E., 1985, Eocene amber from the Pacific Coast of North America: Geological Society of America Bulletin, v. 96, p. 1530-1536.

Nelson, W.H., Prostka, H.J., and Williams, F.E., 1980, Geology and mineral resources of the North Absaroka Wilderness and vicinity, Park County, Wyoming: U.S. Geological Survey Bulletin 1447, 101 p.

Osterwald, F.W., Osterwald, D.B., Long, J.S., Jr., and Wilson, W.H., 1966, Mineral resources of Wyoming: Geological Survey of Wyoming Bulletin No. 50, 287 p.

Platt, R.E., 1947, Little known Wyoming locality: The Mineralogist, v. xv, no. 5, p. 227-230.

Rohn, K.H., 1986, The bounties of Fremont County: Gems & Minerals Magazine, April, p. 26-29.

Root, F.K., 1977, Minerals and rocks of Wyoming: Geological Survey of Wyoming Bulletin No. 56, 84 p.

Sherer, R.L., 1969, Nephrite deposits of the Granite, the Seminoe, and the Laramie Mountains, Wyoming: Ph.D. thesis, University of Wyoming, Laramie, Wyoming, 194 p.

Sinkankas, J., 1959, Gemstones of North America: Van Nostrand Company, Inc., Princeton, New Jersey, 675 p.

Sinkankas, J., 1962, Gem cutting--a lapidary's manual, second edition: Van Nostrand Reinhold Company, New York, 297 p.

Sinkankas, J., 1966, What do we really know about the formation of agate and chalcedony?, *in* The agates of North America, Hugh Leiper, editor: The Lapidary Journal, p. 6-10.

Smith, W.C., and Page, L.R., 1941, Tin-bearing pegmatites of the Tinton district, Lawrence County, South Dakota, a preliminary report, *in* Strategic mineral investigations 1940: U.S. Geological Survey Bulletin 922, p. 595-630.

Spendlove, E., 1982, Sweetwater agate: Rock and Gem Magazine, June, p. 14-17.

Spendlove, E., 1984, Yellow Tree agate: Gems & Minerals Magazine, December, p. 48-51.

Sterrett, D.B., 1923, Mica deposits of the United States: U.S. Geological Survey Bulletin 740, p. 331-333.

Sunderland, K., undated, Shirley Basin petrified wood: Wyoming Field Science Foundation Monograph No. 13, 4 p.

U.S. Geological Survey, 1893, Mineral resources, precious stones, moss agate, Wyoming: U.S. Geological Survey Mineral Resources of the U.S., p. 697.

U.S. Geological Survey, 1903, Mineral resources, precious stones, blue quartz, Wyoming: U.S. Geological Survey Mineral Resources of the U.S., p. 947, 948, and 1346.

U.S. Geological Survey, 1908, Mineral resources, agate, moss agate, etc., Wyoming: U.S. Geological Survey Mineral Resources of the U.S., p. 806.

U.S. Geological Survey, 1914, Mineral resources, gems, and precious stones, Wyoming: U.S. Geological Survey Mineral Resources of the U.S., p. 309-310.

U.S. Geological Survey, 1981, Wyoming geographic names index: U.S. Geological Survey Branch of Geographic Names, 424 p.

Voynick, Steve, 1987a, New Yogo sapphires: Rock and Gem Magazine, August, p. 24-28.

Voynick, Steve, 1987b, Rock Creek sapphires: Rock and Gem Magazine, December, p. 44-50, 79.

Welch, C.M., 1974, A preliminary report on the geology of the Mineral Hill area, Crook County, Wyoming: M.S. thesis, South Dakota School of Mines and Technology, Rapid City, 83 p.

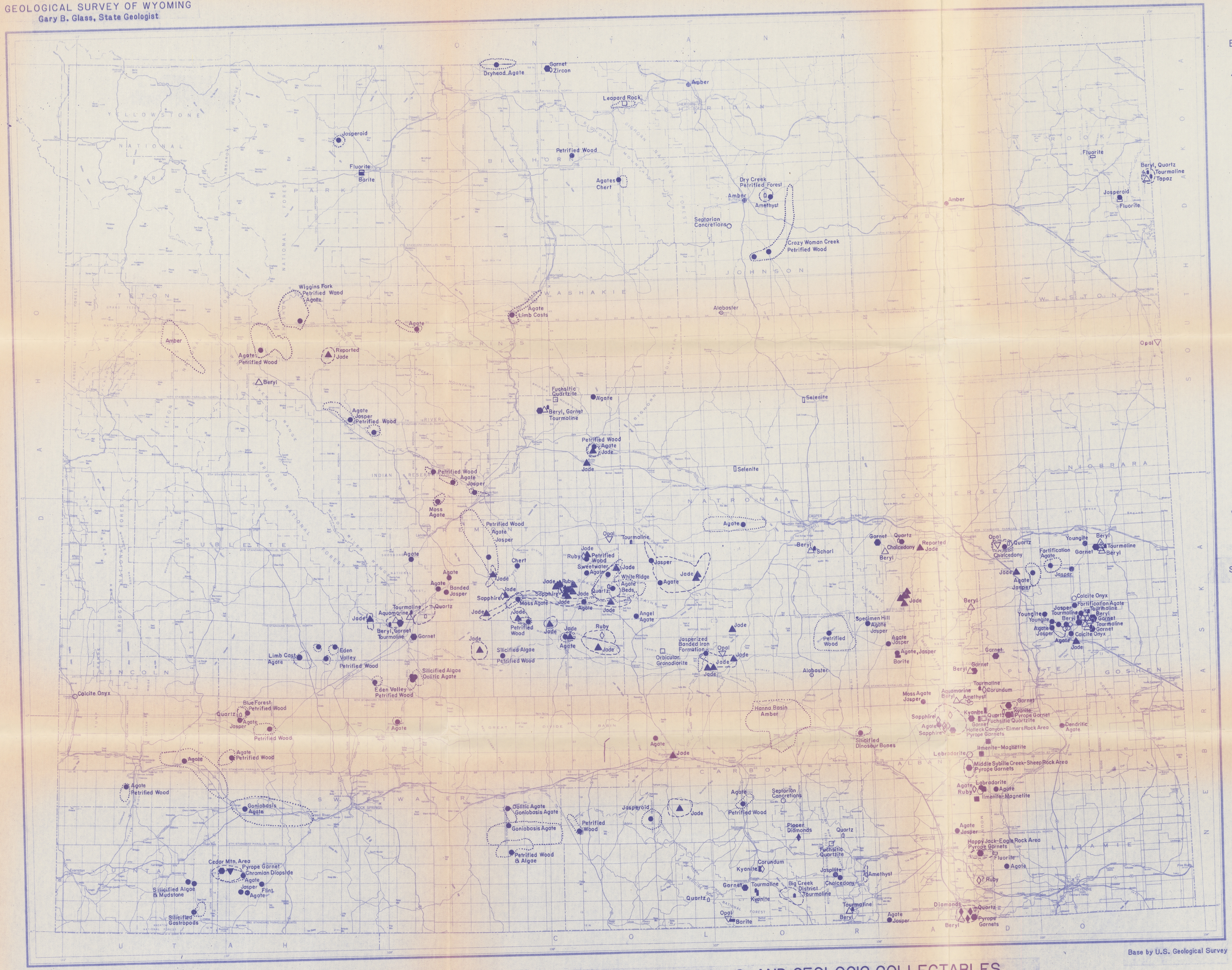
Wilson, W.H., 1951, A beryl and mica pegmatite in the Haystack Range: Geological Survey of Wyoming Mineral Report 51-1 (unpublished), 2 p.

Wilson, W.H., 1965, A field guide to the rocks and minerals of Wyoming: Geological Survey of Wyoming Bulletin No. 51, 72 p.

Zeitner, J.C., 1966, Agates of the Rocky Mountain eastern slope, *in* The agates of North America, Hugh Leiper, editor: The Lapidary Journal, p. 57-59.

GEOLOGICAL SURVEY OF WYOMING
Gary B. Glass, State Geologist

OPEN FILE REPORT 90-9
Sheet 1



Base by U.S. Geological Survey

EXPLANATION

- △ Beryl
- ◇ Corundum
- ◆ Diamond
- ▲ Nephrite Jade
- ▽ Opal
- ▼ Chromian Diopside
- ⬡ Labradorite
- ⬢ Garnet
- Quartz
- Topaz
- Tourmaline
- Zircon
- Barite
- Fluorite
- Selenite
- Kyanite
- Alabaster
- Amber
- ○ Calcite
- ● Chalcedony
- ■ Ilmenite-Magnetite
- □ Rock Groups
- General area of occurrence for gemstone
- General area of occurrence for lapidary material or geologic collectables

See text for details of occurrences

N

10 0 10 20 30 40
Miles

10 0 10 20 30 40 50
Kilometers

Scale 1:1,000,000

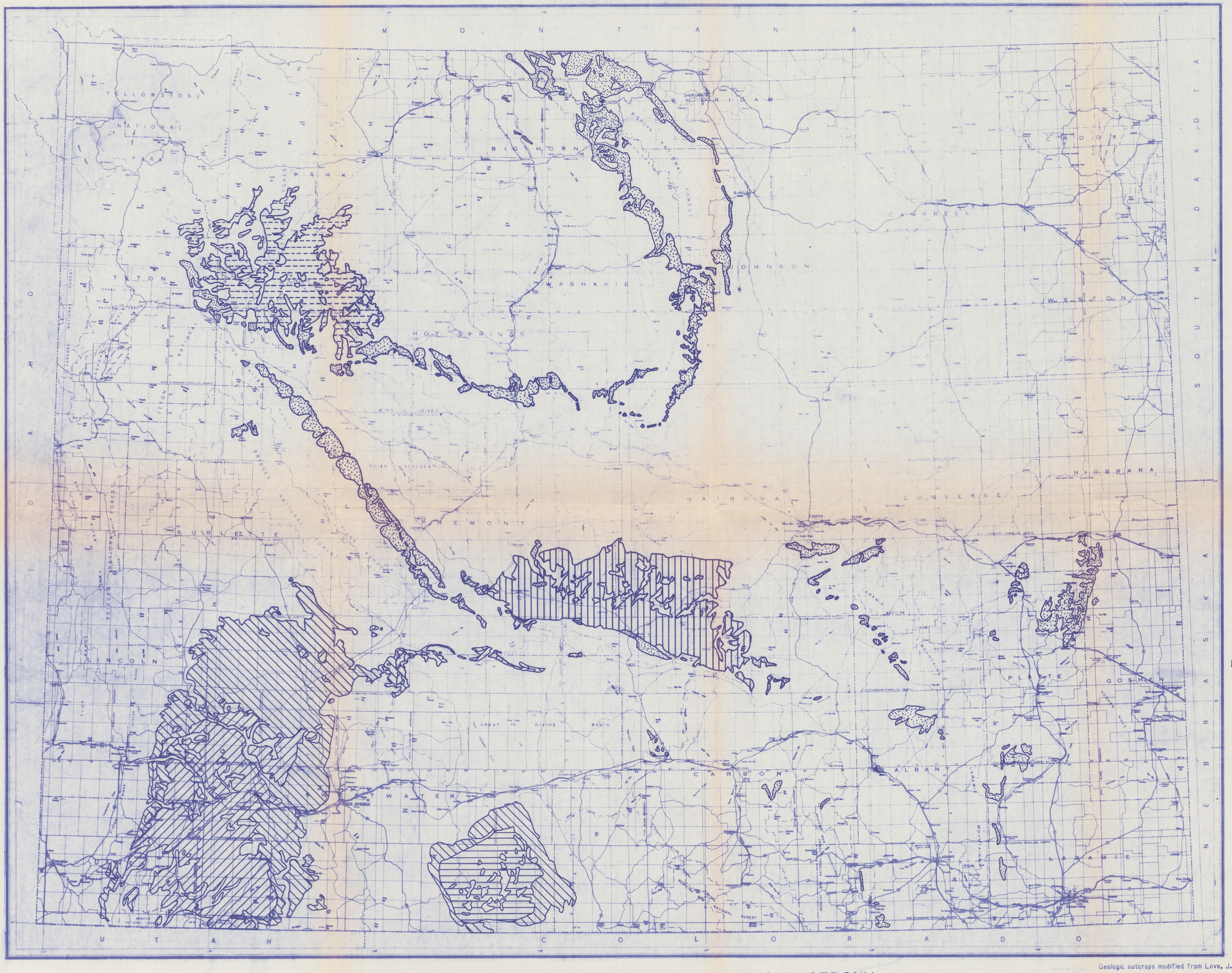
LOCATION MAP OF WYOMING GEMSTONES, LAPIDARY MATERIALS, AND GEOLOGIC COLLECTABLES

by
Wayne M. Sutherland

1990

GEOLOGICAL SURVEY OF WYOMING
Gary B. Glass, State Geologist

OPEN FILE REPORT 90-9
Sheet 2



EXPLANATION

Miocene and younger rocks in central Wyoming including Splitrock Formation, Moonstone Formation, and Bug Formation

Washakie Formation, Eocene

Bridger Formation, Eocene

Laney Member of the Green River Formation, Eocene

Wiggins Formation, Eocene

Paleozoic limestones reported or projected as sources of chalcedony including selected outcrops of Phosphoria Formation, Hartville Formation, Casper Formation, Madison Limestone, Guernsey Formation, and Bighorn Dolomite

N

10 0 10 20 30 40
Miles

10 0 10 20 30 40 50
Kilometers

Scale 1:1,000,000

MAJOR OUTCROPS OF HOST ROCKS FOR WYOMING CHALCEDONY

by

Wayne M. Sutherland

1990

Geologic outcrops modified from Love, J. D., and Christiansen, A. C., 1985, Geologic map of Wyoming: U. S. Geological Survey, Scale 1:500,000