

*Bulletin No. 48*

*Mineral Technology Series No. 17*

*University of Arizona*  
*Bulletin*

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Gems and Precious Stones  
of Arizona

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Entered as second class matter November 23, 1915, at the postoffice at Tucson, Arizona, under the Act of August 24, 1912. Issued weekly, September to May.

PUBLISHED BY THE

University of Arizona  
Bureau of Mines

CHARLES F. WILLIS, *Director*

TUCSON, ARIZONA

1916-17

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# University of Arizona Bulletin

MINERAL TECHNOLOGY SERIES No. 17

FEBRUARY 6, 1917

## GEMS AND PRECIOUS STONES OF ARIZONA

BY FRANK L. CULIN, JR.

### INTRODUCTION

Nearly all the known varieties of gems and precious stones are found in the United States, and several varieties are found in Arizona. Little systematic mining has been carried on for them, and no extensive search for them has been made, except in the states of Maine and North Carolina. In most cases, the discovery of gems in the United States has been accidental in connection with other substances that are being mined, or in small veins.

These gems are mostly sold in local markets; gem collectors and mineralogists also purchase them, for private collections, as a rule.

### ARIZONA GEMS

The best known gems found in Arizona are the turquoise, garnet, peridot, chrysocola, azyr-malachite, malachite, agate, chalcedony, amethystine quartz, diamond (meteoric) diopside and topaz.

*Turquoise:* Turquoise is a phosphate of alumina and copper. As a rule, it has greenish or light milky blue color; also it is commonly a dark blue, which fades on exposure. These varieties are hardly worth the cost of cutting. The gem stone should be a clear dark blue, which will not fade. When veined or mottled with the gangue matrix the substance is known as matrix turquoise. This matrix is usually as hard as, and even harder than, the turquoise itself. The color of the matrix should be pleasing, and harmonize with the blue of the turquoise.

Turquoise occurs as veins or vugs in acid igneous rocks. It seems to have been formed by deposition from warm waters, and is usually associated with altered rocks.

*Garnet:* Garnet is a complex silicate of calcium and aluminum, in which the calcium is frequently replaced by more or less iron and magnesium, and the aluminum, by chromium and iron. It varies in color from white to black-red, yellow, green and brown shades. The best quality garnets are dark red, free from specks and cracks or

other flaws. This variety is called pyrope garnet. When of a purplish tint, it is known as almandine. The brown variety is incorrectly called hyacinthe.

The precious garnet found in Arizona is known as the Arizona Ruby, although it is not at all related to the true ruby; it is as fine as any found in the world. They are gathered as worn, rounded pebbles, in gravel deposits in the northern part of the state, mostly by the Moqui Indians. The gem has not been found in place in this state, but was probably formed in basic rocks, such as peridotite. It also occurs in mica schist rocks in other localities, and may be found in such rocks in this state.

*Peridot:* Peridot is a clear pure crystalline variety of the mineral chrysolite or olivine, a magnesium-iron silicate. The best quality stones have a clear yellow-green tinge. It is usually brown or olive green (olivine) and rarely a clear golden yellow (chrysolite). The material from Arizona comes from altered peridotites, in the northern part of the state, near Ralkai and Rice. It is usually found in sands and gravels. Large good stones are hard to find. The stone is increasing in popularity.

*Chrysocolla:* Chrysocolla is a hydrous silicate of copper. It is not of much value as a gem stone unless it has been silicified. It is of a light blue color, usually, or it may be more or less mottled. It is found in many copper mines of the state, being very abundant in the Globe district.

*Azurite and Malachite:* Azurite and malachite are hydrous silicates of copper. Azurite is the blue carbonate, and malachite green. The two minerals are nearly always very closely associated, and the combination is known as azure-malachite. Malachite is most valuable when it shows rounded or oval workings and a silky lustre. These minerals are common in the copper mines of Arizona.

*Agate:* Agate is a variegated chalcedony which is a variety of quartz. The variegations usually take the form of bands, which, when parallel and of alternating colors, form onyx and sardonyx. When these variegations take the form of moss-like or dendritic growths, the mineral is called moss agate. It is usually formed by successive deposition in cavities in eruptive rocks. They are found in many places in the state; in place in lavas, in sands and gravels, and embedded in limestones.

*Chalcedony:* Chalcedony is quite common in Arizona, usually

of a bluish gray or buff color. The red variety, carnelian, and the green variety, chrysoprase, have not been found in Arizona. It is formed in rock cavities, and found in place or in sands and gravels. A variety of chalcedony known as "turtle-back" or moonstone has been found here. It shows a peculiar mottled appearance, when cut, resembling the back of a turtle. Chalcedony is often called moonstone when cut, but improperly so.

*Amethystine Quartz*: Amethystine quartz is a clear purple colored quartz. The best known occurrence is in the McConnico district. According to the Mineral Resources of the United States for 1908, one crystal from this district was sold to Tiffany, of New York City, for \$59.00. The great objection to it as a gem is that it loses color. It is found in veins and vugs, often with silver and lead ores.

*Diamond*: The only diamonds found in Arizona are meteoric, and occur in meteoric iron found at Canyon Diablo, near Coon mountain, in the northern part of the state. The crystals are very small, and have no commercial value.

At one time, in 1870, a company was organized for the exploration of diamonds and other gems in Arizona and New Mexico. A great quantity of gems said to have been found in these fields was exhibited, and expeditions to the locality gathered approximately 6000 carats of rubies and 1000 carats of diamonds.

*Topaz*: Topaz is a fluo-silicate of aluminum, usually clear and colorless, but most valuable when golden yellow or blue in color. It is found in the northern part of Arizona. The golden yellow variety is very apt to fade.

#### METHODS OF EXTRACTION AND PREPARATION.

Most of the gems and precious stones found in Arizona are merely by-products of the mining of other substances, and are sorted out from poorer specimens. The turquoise, garnet and peridot are mined separately. There are several companies that have produced turquoise in Arizona. The garnets are gathered from the sand and gravel beds in which they are most commonly found.

In preparing precious stones for market, the best specimens are first selected, cleaned, cut in various shapes, and polished. Poorer specimens are also cut and polished, or they may be reserved for use in private and public collections.

## THE GEM INDUSTRY.

There was a large decline in the gem industry in 1914, due to the restricted conditions imposed by the conflict in Europe. This decrease had not been expected, but nevertheless, almost all gems fell off in production; turquoise, however, showed an increase.

The total value of the gem production of 1914 was \$124,651. The following table shows the total value of the production of gems which, although found in Arizona, may or may not be produced in the state.

Agate .....	\$ 8,312
Amethystine quartz .....	255
Azurite .....	1,280
Chalcedony (Included with agate)	
Chrysocolla (Included with azurite)	
Dioptase (Included with azurite)	
Garnet .....	1,760
Malachite (Included with azurite)	
Peridot .....	100
Topaz .....	1,380
Turquoise .....	13,370
<b>Total .....</b>	<b>\$26,457</b>

(Note. It is to be understood that this does not represent the Arizona production. No figures as to that are available.)

The value of the imports of precious stones into the United States in 1914 was \$19,211,084, showing a decrease of \$26,220,914 from 1913.

## ESSENTIAL PROPERTIES OF GEMS.

Gems are certain minerals which, by reason of their brilliancy, hardness and rarity, are valued for personal decoration; the term is extended to include pearl. (Definition from Encyclopedia Britannica). In a restricted sense the term is applied only to precious stones after they have been cut and polished as jewels, while in their raw state, the minerals are conveniently called gem stones.

The general properties which determine the value of a gem are: (1) hardness; (2) specific gravity; (3) crystalline form and cleavage; (4) color; (5) optical properties, refraction and dispersion.

(1) Hardness—A high degree of hardness is a desirable property of a gem, for no matter how brilliant and beautiful a mineral may

be, it is less valuable to the jeweler if it is not sufficiently hard to withstand the abrasion to which articles of personal use are subjected. (This statement does not apply to pearls and a few other gems.) If not sufficiently hard, the stone may be badly scratched; it will at least soon become dull by wear. An arbitrary scale of hardness has been adopted, with the diamond, the hardest known gem, placed at the top with a value of 10. The ruby and sapphire come next, with a value of 9; the topaz is placed at 8, and quartz at 7.

(2) Specific gravity: This property in itself does not directly affect the value of a gem stone, but it is very valuable in distinguishing one stone from another.

(3) Crystalline form and cleavage:: The majority of gem stones are crystalline in character. They lose their original crystalline form in cutting, but due to the crystalline structure, most gem stones have definite cleavage planes. This property is usually taken advantage of in dressing stones preparatory to cutting.

(4) Color: The beauty and consequent value of gems depend mainly on their color. Some stones, of course, as the diamond, are valued for absence of color, but this is the exception. Color is usually due to the presence of some foreign pigmentary matter, usually in small proportions. The coloring matter may be evenly distributed throughout the stone, or in regular zones, or in quite irregular patches.

(5) Optical properties: Refraction. The brilliancy of a cut stone depends on the amount of light reflected from its faces; in the form known as the "brilliant", the gem is so cut that much of the incident light, after entering the stone and suffering refraction, is totally reflected from the facets at the back. The amount of light which is thus returned to the eye of the observer will be greater as the angle of total reflection, or critical angle, is smaller, but this angle will be small if the refractive power of the stone is great; so that the brilliancy depends directly on the refractivity.

Dispersion: The play of colors exhibited by a cut stone, often known as its "fire", is due to the decomposition of the white light which enters the stone, and is returned, by internal reflection, after resolution into its colored components.

#### VALUE OF GEMS

##### *Wholesale Prices:*

Turquoise is worth up to \$100 a pound at the mine, in the rough, but usually is less valuable. Matrix material brings from \$5 to \$25 per pound. Cut matrix turquoise costs from 10 cents to \$10 a

carat. Cut clear blue turquoise costs from \$1 to \$10 a carat, the price increasing with size. When cut in large quantities, stones may be cut for three to five cents a carat.

Garnet is sold in the rough as single stones, and brings a price rather less than one fifth the price of cut stones. Cut pyropene garnets are worth from 50 cents to \$2 a carat, depending on the quality. Almandine garnets, if resembling the emerald, cost \$12 to \$15 a carat. The cost of cutting is \$1 to \$1.50 per carat.

Peridot is also sold as separate stones. Cut material runs from \$2 to \$15 a carat. \$5 usually buys a good stone. Cutting costs from \$1 to \$1.50 a carat.

Copper bearing stones, excluding high grade malachite, sell for about \$10 a pound. When cut, they are sold by the stone rather than by carat, and are sold so as to make a profit. No definite price can be set. They cost from five cents to ten cents a carat for cutting.

Chalcedony, unless of the turtle back variety, is hardly worth \$1 per pound. Cut material is barely worth the cost of cutting, which is 5 to 10 cents a carat. Turtle back variety may bring \$5 or more for a stone.

Amethystine quartz is almost valueless, except as mineral specimens unless it holds its color. The cut American material is hardly worth more than the cost of cutting. But foreign material may be worth \$4 a carat when cut. The cost of cutting is from 50 cents to \$1 a carat.

Topaz is bought by the single stone. Fine gem crystals, when colored, may be worth \$50 to \$100. Cut material, in dark blue shades, brings \$10 to \$25 a carat; the fine golden yellow brings \$4 a carat; diamond cut white stones bring \$1 to \$2 a carat. The cost cutting is about \$1 a carat.

#### ECONOMIC CONSIDERATIONS

With the exception of a very few valuable and highly prized stones, the production of gems is almost always more or less spasmodic. The cause of this is usually over production during a period of demand. This over production is often purposeful—as an example, the tourmaline mines of San Diego County, California, produce a large supply, which provides for the market demands for a time, and when this supply runs low, the mines are again operated until the stock is replenished.

In figuring upon a deposit of gems or precious stones, usual precautions must be taken. The product must, of course, be of good quality. The demand for the material should be known and a



market arranged for. The question of transportation does not enter, to any great extent, since the bulk is not large, and the quantity small.

#### FUTURE OF THE INDUSTRY

There is no question but that there will always be a large demand for gems. Aside from a few varieties, as the diamond, ruby, pearl, sapphire, etc., the demand is quite variable, but is always sufficient to repay small efforts in the production of various stones.

In Arizona the turquoise and garnet are sure of a wide market, at almost all times. Gems of the copper group, azurite, malachite, diopase, etc., will find a market, not always steady, but fairly so, especially with curio seekers.

Although there is, as has been seen, quite a wide variety of gems and precious stones in Arizona, one could hardly say that prospects of any great or continued production are good. What production there is will probably always be on a small scale.