What Is a Diamond?
Welcome!

Diamond has to go through a lot before it reaches the jeweler’s display case. It forms deep in the earth under extreme heat and pressure. It’s transported violently upward until it arrives at or near the earth’s surface, where it’s forced from its hiding place by nature or by man. Then it’s cut and polished until its natural beauty shines through.

Today, we’ll look at some of this information and answer the following questions:

• What is diamond?
• How do diamonds form?
• How do diamonds reach the surface?
• What are common rough diamond shapes?
• What are the characteristics of rough diamond?

We’ll also learn a little about the Gemological Institute of America (GIA) and what GIA does to support the gem and jewelry industry.
What Is a Rock?

Rocks are a combination of minerals and are the building blocks of the earth. They tell a story about the earth and how it was formed. Some rocks form at or near the earth’s surface and others form deep in the earth’s crust or in the middle layer of the earth called the mantle.

Although there are many kinds of rocks, geologists classify them into three groups based on how they’re formed:

**Igneous** rocks, such as lava, obsidian, pumice, and granite, start out in a molten or semi-molten state and become solid when they cool.

**Sedimentary** rocks, like sandstone, shale, and limestone, are formed by layers of sediments squeezed and pressed together over a long period of time.

**Metamorphic** rocks, such as slate, schist, and marble, have their makeup, texture, or structure changed by great heat, pressure, or both.
What Is Diamond?

Diamond’s splendor has been appreciated for centuries, but there was not much scientific knowledge about it before the twentieth century.

Until the late 1700s, diamond posed a challenge to scientists. What was this hard, beautiful, mysterious substance made of?

Scientific experiments proved that diamond is made of carbon. Carbon is an element, which is something that cannot be broken down into simpler components.

Carbon is one of the most abundant elements.

Diamond isn’t the only material that’s made of carbon: Graphite is, too.
What Is Diamond?

The differences between diamond and graphite lie in the way their carbon atoms are connected. (The blue lines in the illustrations represent those invisible electronic connections.)

In graphite (bottom), the atomic bonds within the layers are fairly strong, but the bonds between the layers are weak. The weak bonds allow movement between the layers and makes the resulting material “slippery.” This is why graphite is an excellent lubricant.

In diamond (top), there are strong bonds in all directions. This makes diamond the hardest substance on earth.
Mohs Scale of Hardness

In 1822, a German professor and mineralogist named Friedrich Mohs (MOZE) developed a system for rating the relative hardness of minerals. Because diamond scratched every other mineral, he gave it the number 10.

The Mohs scale can be confusing. Without knowing anything else about the minerals on the list, you might think that diamond is only a little harder than corundum. In fact, destructive scratch tests done with a diamond-tipped, weighted lever show that diamond is 140 times harder than corundum and almost 124,000 times harder than talc.

Many everyday items measure about a 7 on the Mohs scale, like a drinking glass, for example. Any gem that has a lower Mohs scale rating than topaz might pick up some scratches from even the most careful wear. Even scratchy fabrics like wool can, over time, strip away the lustrous outer layer of a pearl.
The Earth's Layers

Diamonds are formed deep within the earth, so let’s take a closer look at the earth’s layers for a moment. The earth’s first layer is the crust.

The crust is the layer of hard, strong rock that’s extremely thin compared to the layers beneath it. Its thickness ranges from about 3 to 25 miles (5 to 40 kilometers), although it can be much thicker under mountain ranges. The crust is thinnest under the oceans (oceanic crust).

The mantle is divided into two sections: the upper mantle and the lower mantle. The lower mantle is close to the core, while the upper mantle is close to the crust.

Structurally, the mantle is rocky near its outer surface and more fluid at its deeper levels.

At the center of the earth is the core, which consists of a molten (melted) layer and a solid center.

Next, let’s look at the specific conditions required for diamond formation.
The Right Conditions

From the earth’s crust to its core, both heat and pressure increase.

The conditions required for natural diamond formation are a temperature range of 2102°F to 2192°F (1150°C to 1200°C) and pressure between 50 and 70 kilobars.

A kilobar is a unit that scientists use to measure extremely high pressure. The normal, everyday pressure on Earth is equal to one bar, which is just slightly less than one atmosphere. An atmosphere is equal to the effect of a 14.7-pound weight on an area of one square inch. So a kilobar—1,000 bars or almost 1,000 atmospheres—equals about 14,700 pounds per square inch (psi).

The right temperature and pressure conditions exist in very limited areas of the earth’s upper mantle, between 90 and 140 miles (about 140 and 220 kilometers) beneath the surface.

At that depth, those ideal conditions work together to force carbon atoms to form the extremely strong bonds found in diamond crystals.
The Right Location

The right temperature and pressure conditions for diamond formation exist only under large, geologically stable parts of the crust called cratons.

Conditions under a craton are stable enough to preserve diamonds for hundreds of millions of years after formation.

This map shows the distribution of cratons around the world. Some of them contain diamond-bearing deposits, and some don’t.

Notice that there are no cratons under the ocean.
Transport Rock

After formation, if conditions remain constant, diamonds might remain underground for hundreds of millions of years before they’re carried to the surface.

Diamond deposits are found in two types of rock: kimberlite and lamproite.

**Kimberlite**—An igneous rock that transports diamonds to the surface.

**Lamproite**—An igneous rock, rarer than kimberlite, that transports diamonds to the surface.

Their mineral and chemical compositions are fairly similar. The main difference between them is that, while kimberlite tends to occur in the middle of cratons, lamproite is commonly found at the edges of cratons, or even in the zones immediately around them.

It’s important to remember that kimberlites and lamproites aren’t the rocks that diamonds form in—they merely carry already-formed diamonds to the surface.
Emplacement

The geologic process that delivers materials to the earth’s surface is called emplacement.

Emplacements have pushed kimberlites and lamproites up to Earth’s surface for billions of years—at times, they carried diamonds with them.

The first diamond-bearing emplacement probably occurred more than 2.5 billion years ago.

The most recent was probably around 20 million years ago.

1. After formation, diamonds might wait underground for millions of years.
2. Then a violent eruption brings them to the surface.
3. The eruption results in a diamond-bearing crater over an extremely deep pipe.
4. Once a diamond deposit reaches the surface, it might be millions of years more before someone discovers it and begins building a mine.
Reaching the Surface

As kimberlite blasts through the crust, it creates a deep carrot-shaped formation called a pipe. Lamproite emplacement works the same way, but its pipe is wider at the top, so it looks more like a champagne glass or a mushroom than a carrot.

The kimberlite—or lamproite—doesn’t flow out of the pipe like lava from a volcano. It solidifies while it’s still very hot, so by the time it reaches the surface it has changed from liquid to solid.

The explosion is a mixture of solid rock, ash, and gases. After the material explodes through the overlying rock, most of it falls back into its pipe, along with the diamonds it’s carrying.

What’s left is a deep diamond-bearing pipe, topped off by a shallow crater.

Kimberlites are widespread—in the 1990s, there were about 6,000 of them known worldwide.

But fewer than 1,000 of them contained any diamonds. Of those, only about 50 had enough diamonds to be economic, and only about 20 are still being mined today.

With statistics like that, you can see why diamonds are considered rare and precious!

This is the Aikhal pipe in Russia. In 2005 underground mining began at the site.
The Kelsey Lake diamond mine in Colorado is no longer in operation, but it may still hold countless gem-quality diamonds.

The Argyle underground mine in Australia is one of the most technologically advanced mines in the world.

Aerial view of two open-pit mines at the Diavik diamond mine.
Diamond Quality

Not all diamonds are the same. In fact, most diamonds lack the qualities to be considered for use in jewelry. Rough diamonds are categorized broadly into three categories:

- Gem Quality
- Near Gem Quality
- Industrial

A very small portion of the earth’s diamonds are considered to be gem quality. In fact, only about 15% of all diamonds pulled from the earth are gem quality. 39% are considered near gem quality while the remaining 46% are industrial quality.
Crystal System

Regular, repeating patterns of atoms form an internal arrangement called the crystal structure or crystal lattice.

Crystal structure greatly affects a mineral’s characteristics. The diamonds in a million-dollar tiara and the graphite in a 10-cent pencil are made of exactly the same element—carbon—and the same kinds of atoms. However, diamond and graphite form in different crystal structures.

Mineralogists and gemologists classify crystals by their geometric properties and the symmetry of their internal crystal structures.

The categories are called crystal systems. Diamonds belong to the cubic system, also called the isometric system. The cubic system is the most symmetrical: Well-formed cubic crystals are evenly proportioned and balanced.

The symmetry of diamond’s crystal structure, which shows in the outward appearance of diamond rough, makes it a unique member of the gem world.
Mathematicians and mineralogists created the names for geometric and crystal forms by using the Greek words for numbers and shapes. When used this way, the Greek words are called "roots." Once you recognize the Greek roots, you’ll be able to recognize the words made from them. The number roots are:

- Tris = 3
- Tetra = 4
- Hexa = 6
- Octa = 8
- Dodeca = 12

Individual roots can be combined to make roots for larger numbers:

- Tetrahexa = (4×6) = 24
- Trisocta = (3×8) = 24
- Hexocta = (6×8) = 48

Next, add the base word "hedron," which means "face." So an octahedron has 8 faces, a dodecahedron 12, and a trisoctahedron 24.
Crystal Shapes

The basic crystal shape of a mineral is called its habit. The habit of gem-quality diamond is most often the octahedron.

Perfect diamond octahedrons are among the most striking of all mineral crystals. A well-shaped, transparent, octahedral diamond crystal with sharp, square edges is called a glassie.

While the most common habit of gem diamond is the octahedron, perfectly shaped octahedral rough is quite rare.
**Across**

2. One of the December birthstones
3. A birthstone thought to provide powers of prophecy
5. Unit of measurement for gem weight
8. A tabletop magnifier
10. A gem’s ability to withstand wear, heat, and chemicals

**Down**

1. A person who studies mineralogy
4. An organic gem that is the birthstone for June
6. The basic unit of all matter
7. A small, portable magnifying lens
9. The city where GIA headquarters is located
Birthstones and Lore

What's your birthstone?

On the following pages you will find out the hardness of your birthstone based on the Mohs scale, and which powers your special stone is said to have.
<table>
<thead>
<tr>
<th>January</th>
<th>Garnet</th>
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<tbody>
<tr>
<td>Garnet comes in many different colors. The name garnet is derived from the word pomegranate, because the deep red varieties of the gemstone resemble the seeds of the pomegranate fruit. A green variety, called tsavorite, was found in 1971 in Kenya’s Tsavo National Park. Garnet is believed to bring a sense of calm, when worn. Hardness 7–7½</td>
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<table>
<thead>
<tr>
<th>April</th>
<th>Diamond</th>
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<tbody>
<tr>
<td>Diamond is the hardest of all gemstones. They form deep within the earth and reach the surface through violent volcanic eruptions. Some diamonds are more than three billion years old, which is likely the reason that they represent endurance. Hardness 10</td>
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<tr>
<th>February</th>
<th>Amethyst</th>
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<tr>
<td>Amethyst is the purple variety of quartz. The ancient Greeks associated the mineral with Bacchus, the god of wine. It was believed that wearing amethyst would keep the drinker sober. Perhaps the modern sentiment, that amethyst brings power to the wearer, derives from this sense of being clearheaded. Hardness 7</td>
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<tr>
<th>May</th>
<th>Emerald</th>
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<tr>
<td>Emerald is among the most valuable of gemstones. This blue-green variety of beryl was once believed to heal ailments of the eyes. Colombian emerald mines are legendary and continue to produce the finest specimens. An emerald always brings joy to the wearer. Hardness 7½–8</td>
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<tr>
<th>March</th>
<th>Aquamarine, Bloodstone</th>
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<tr>
<td>Aquamarine is the blue to greenish blue variety of the mineral beryl. Its name is derived from two Latin words: aqua, meaning “water,” and marina, meaning “of the sea.” Crystals can grow quite large allowing the gem cutter to fashion sizeable gems. It is believed to represent unity. Hardness 7½–8</td>
<td></td>
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<tr>
<td>Bloodstone is semitranslucent to opaque dark green with red to brownish red spots. Bloodstone is believed to help stop blood flow from wounds, give courage and wisdom to its wearers, and enable them to uncover enemy plots. Hardness 6½–7</td>
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</tbody>
</table>
Pearl
Pearl is different from other gems because it forms in the soft tissue of a living mollusk. Natural pearls are rare; most pearls are cultured by implanting a bead into the mollusk and letting the mollusk coat the bead with nacre for up to two years before the pearl is harvested. Wearing pearls is believed to bring clarity to the mind.
Hardness 2½–4

Moonstone
Moonstone is colorless to white, occasionally green, orange, yellow to brown, or gray to nearly black. Moonstone is believed to bring good fortune, cure epilepsy, encourage serenity, and even help swimmers avoid accidents in the water.
Hardness 6–6½

Alexandrite
Alexandrite changes color under different lighting. In daylight or fluorescent light it looks yellowish, brownish, grayish, or bluish green; in incandescent light it looks orangy or brownish red to purple-red. Alexandrite is thought to help cure spleen and pancreas disorders. Alexandrite pulls sacred fires together and stabilizes them.
Hardness 8½

JUNE

Ruby
Ruby is esteemed among gems because of its rich red color. The finest examples come from Myanmar (Burma). In ancient times, rubies were believed to give the wearer strength and courage in battle. They are also considered a source of harmony.
Hardness 9

JULY

Peridot
Peridot is the gem variety of the mineral olivine. The most ancient source of fine peridot is a tiny island in the Red Sea known as Zabargad. Peridot has also been recovered from meteorites. It is believed to bring purity when worn.
Hardness 6½–7

Spinel
Spinel comes in a painter’s palette of colors: orange, intense “stoplight” red, vibrant pink, and all shades of purple, blue and violet through bluish green. Fine specimens became the treasured property of kings and emperors. Spinel is believed to promote health.
Hardness 8

Sardonyx
Sardonyx is semitransparent to opaque with white or black bands alternating with reddish brown bands. Sardonyx is believed to protect its wearer from bites of venomous snakes and gives one the power of eloquence. It attracts quality friends and cures insomnia.
Hardness 6½—7

AUGUST

Sapphire
Sapphire comes in every color of the rainbow, although blue sapphire is the most popular. Also prized is the rare pink-orange sapphire variety known as padparadscha, named after the color of a lotus flower. Sapphire represents loyalty.
Hardness 9

SEPTEMBER

Peridot
Peridot

Spinel
Spinel

Sardonyx
Sardonyx

Sapphire
Sapphire

Ruby
Ruby
**OCTOBER**

**Opal**
Opal may exhibit a spectrum of colors called play-of-color. When this is set against a dark background, it is known as black opal. Australia is the source of most of the world’s fine opal. Opal represents hope.
Hardness 5–6½

**Tourmaline**
Tourmaline exhibits a wide range of colors. Bicolored and multicolored crystals are common. Sometimes crystals are green on the outside and pink inside; these are called watermelon tourmalines. Wearing tourmaline is believed to bring strength.
Hardness 7–7½

**NOVEMBER**

**Topaz**
Topaz is widely known for its golden color but it can also be found in blue and pink. Regardless of the color, it is believed to bring prosperity when worn.
Hardness 8

**Citrine**
Citrine is the golden yellow variety of quartz. Most citrine is produced by heating amethyst. Brazil is its main source, but it’s also found in many African countries such as Zambia, Namibia, and Madagascar. Wearers of citrine may experience heightened awareness.
Hardness 7

**DECEMBER**

**Zircon**
Zircon is transparent and can be colorless blue, yellow, green, brown, orange, red, and occasionally purple. Zircon is believed to dispel sadness and insomnia and increase the wearer’s riches, honor, and wisdom.
Hardness 6–7½

**Turquoise**
Turquoise contains copper which is the source of its blue or greenish blue color. Many minerals, such as variscite, naturally resemble turquoise. Other minerals can be dyed to imitate it. Turquoise imparts peace upon the wearer.
Hardness 5–6

**Tanzanite**
Tanzanite (a variety of the mineral zoisite) was discovered in 1967 in northern Tanzania, which remains the world’s only known source. Its velvety, purplish blue color sets it apart from all other gems. Tanzanite is said to give its wearers balance.
Hardness 6–7
About GIA

GIA is a school and a laboratory. Many scientists and teachers work there. GIA has been teaching students gemology (the study of gemstones), developing equipment, and setting standards in the gem and jewelry industry since 1931.

People who want to work in the gem and jewelry industry come from all over the world to study at GIA. They learn how to identify and evaluate gems and how to design and make jewelry.

GIA has the world’s largest gemological library. It’s called the Richard T. Liddicoat Gemological Library and Information Center. The library collects and preserves books about gems and jewelry. It has more than 57,000 books. The oldest one dates back to 1496.

GIA also collects and preserves mineral specimens, jewelry, gem art, and gemological equipment.

Their schools around the world have beautiful gems on display.
GIA’s mission is to ensure the public trust in gems and jewelry by upholding the highest standards of integrity, academics, science, and professionalism through education, research, laboratory services, and instrument development.

GIA was established in 1931 by Robert M. Shipley. Mr. Shipley wanted to create an institute to educate jewelers and the world about gems and jewelry. GemKids is just one part of his legacy.

Do you want to become a gemologist? Keep exploring the world of gems and jewelry. Be sure to visit gemkids.GIA.edu.