

Diamonds

Diamonds are formed from pure carbon, one of the most abundant elements on planet Earth. Diamonds, even from ancient times, have been sought for their extraordinary hardness (they are the hardest substance known) and their brilliance, especially in the colorless transparent gemstone variety. Ironically the other form of pure carbon is graphite, which is very soft with a soapy feel and a dull gray color. Graphite is commonly the "lead" in a pencil.

[Mohs Hardness Scale](#) of minerals starts at 1 (talc) and ranges to 10 (diamond). That does not mean that diamonds are ten times harder than talc; mineral number 9 on the Mohs scale is corundum, a class of minerals which includes rubies and sapphires. Diamonds can be from ten to hundreds times harder than corundum. Diamonds themselves vary in hardness; for example, stones from Australia are harder than those found in South Africa.

The four main optical characteristics of diamonds are transparency, luster, dispersion of light, and color. In its pure carbon form, diamond is completely clear and transparent. As in all natural substances, perfection is nearly impossible to find. Inclusions of other minerals and elements cause varying degrees of opacity. The surface of a diamond can be clouded by natural processes, such as the constant tumbling and scraping in the bed of a river.

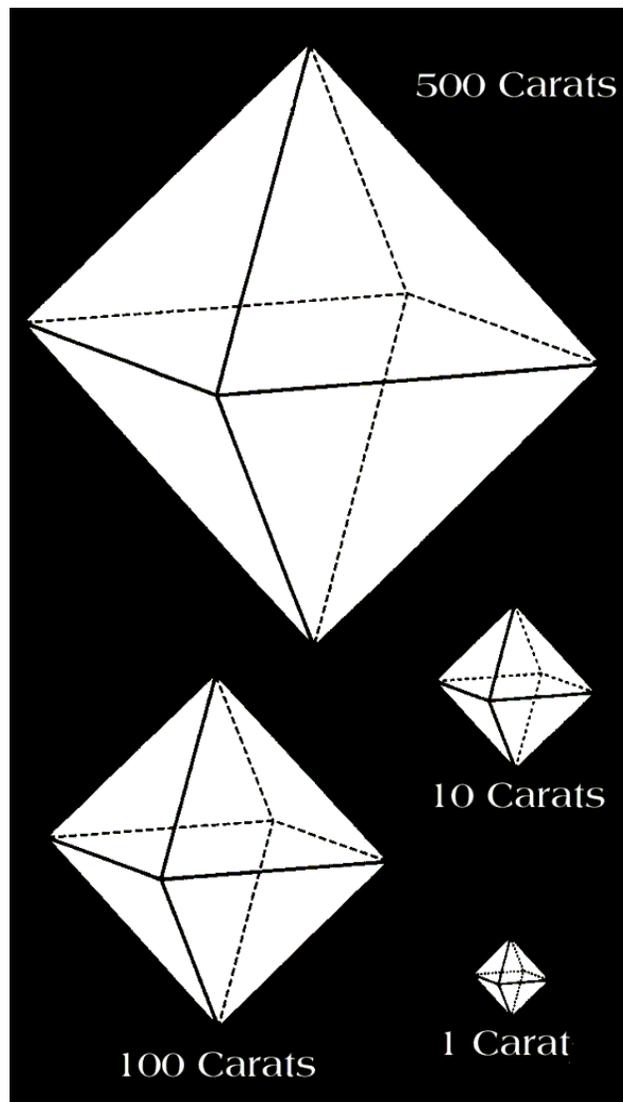
Luster is the general appearance of a crystal surface in reflected light. Luster of a smooth crystal face of diamond is strong and brilliant. It is intermediate between glass and metal and has its own special term--adamantine.

The process of white light breaking up into its constituent colors is called dispersion. Diamonds have strong dispersion, which along with their strong luster, causes the beautiful play of colors so often referred to as the "fire" of a diamond.

Gemstone varieties of diamond are usually clear and colorless, often containing minor inclusions and imperfections. Yellow or yellowish-brown and even brilliant yellow diamonds have been found. Very rarely, diamonds are blue, black, pale green, pink, violet, and even reddish.

The most famous blue diamond, the Hope Diamond, is intertwined with Colorado's mining history. Thomas Walsh, discoverer of the rich Camp Bird Mine near Ouray, purchased the Hope Diamond for his wife in the early 1900s; it was later given to his daughter, Evelyn Walsh McLean who wore it almost continuously until the 1940s. The 45.5-carat Hope Diamond now resides at the National Museum of Natural History in Washington, D.C.

Diamonds, in their perfect cubic crystal form, occur as isolated octahedral (eight-sided) crystals (see figure below). Many variations on the cubic form are found in nature, including twelve-sided crystals and a flattened triangular shape known as a macle. Gemologists recognize three main varieties of diamonds: ordinary, bort, and carbonado.



Size comparison of octahedral diamond crystal
for 1 to 500 carats.

Ordinary diamonds occur as crystals often with rounded faces, from colorless and free from flaws ("the first water"*) to stones of variable color and full of flaws. Bort diamonds occur in rounded forms without a good crystal structure. They are generally of inferior quality as a gemstone. Carbonados are black opaque diamonds usually from the Bahia Province of Brazil. They are crystalline but do not possess the mineral cleavage found in ordinary diamonds.

** An expression which refers to the highest quality diamonds and has come to mean the highest quality of just about anything.*

Diamonds form in nature only under the extreme conditions found in the upper mantle at depths of 150 to 200 kilometers (possibly down to 300 kilometers): pressures of greater than 50 kilobars (50,000 x normal atmospheric pressure) and temperatures of 900 to 1,300°C and possibly higher. The diamonds form as minerals within rocks of the upper mantle called eclogite and peridotite. Eclogite is a coarse-grained rock consisting of red garnet (almandine-pyrope) and a green pyroxene (omphacite). Peridotite is believed to be the most common rock of the upper mantle; it contains varying amounts of three minerals, olivine, orthopyroxene and clinopyroxene. The olivine rich peridotite is called dunite, and the pyroxene rich rock is called websterite. The rock harzburgite contains up to 40 percent orthopyroxene and 60 to 90 percent olivine and is thought to be the most common host rock for diamonds.

If diamonds are formed at depths of 150 to 200 kilometers in the upper mantle, how do they get to the surface of the earth? They are brought to the surface in a peculiar igneous rock called kimberlite (named after the diamond-bearing region of Kimberly, South Africa where these rocks were first identified.) Kimberlites are intrusive bodies that originate in the upper mantle and are injected upward through the upper mantle and the lower and upper crust, eventually reaching the earth's surface as a small volcanic complex (see figure on p. 3). Kimberlites have three facies correlative to their position in the mantle and crust: the root facies, the diatreme facies, and the crater facies. The shape of the kimberlite shown in the figure is similar to that of a carrot or a pipe; a comparatively wide upper zone, up to several hundred meters in diameter, in the diatreme and crater facies; to a lower zone, which narrows into a thin intrusive dike, possibly only a meter thick, in the root facies. The forceful intrusion of the kimberlite brecciates* the surrounding rocks of the upper mantle and crust and incorporates them as xenoliths (xenolith literally means "foreign rock"). Often these xenoliths of the upper mantle peridotites or eclogites contain diamonds.

** Means to break apart into smaller angular fragments. A rock composed of angular fragments is referred to as a breccia.*

Diamonds, being mostly pure carbon, are not amenable to modern methods of age-dating rocks (Carbon 14 dating methods are useful with materials less than about 50,000 years. Most rocks are millions to billions of years old. With recently developed age-dating techniques, the small inclusions of other minerals in diamonds (such as garnet) can be dated. Recent dating of inclusions in diamonds from kimberlite pipes, mainly in South Africa and Australia, indicate that diamonds formed as early as 3,300 million years ago to as late as 990 million years ago, an extended period of the earth's history. The kimberlite, which carried the diamonds to the surface and is the present host rock, was intruded only about 100 million years ago.

Kimberlites ascend rapidly to the earth's surface at rates thought to be on the order of 10 to 30 kilometers per hour. There is usually no evidence of any substantial thermal reaction with the surrounding country rock. In the near surface environment, velocities may increase to several hundreds of kilometers per hour because of gas expansion in the

ascending magma and reaction with water. Craters, tuff rings, and maars form as the highly charged kimberlite magma erupts at the surface.

Kimberlites, though rare, are widespread throughout the surface of the earth. Most well known diamond producing pipes are small, 12 to 75 acres, and they generally occur in clusters of six to forty pipes. Almost all diamond bearing kimberlites are found in the ancient stable cratons of the continents, never in oceanic crust or in younger mountain belts, like the Alps or the Sierra Nevada in California.

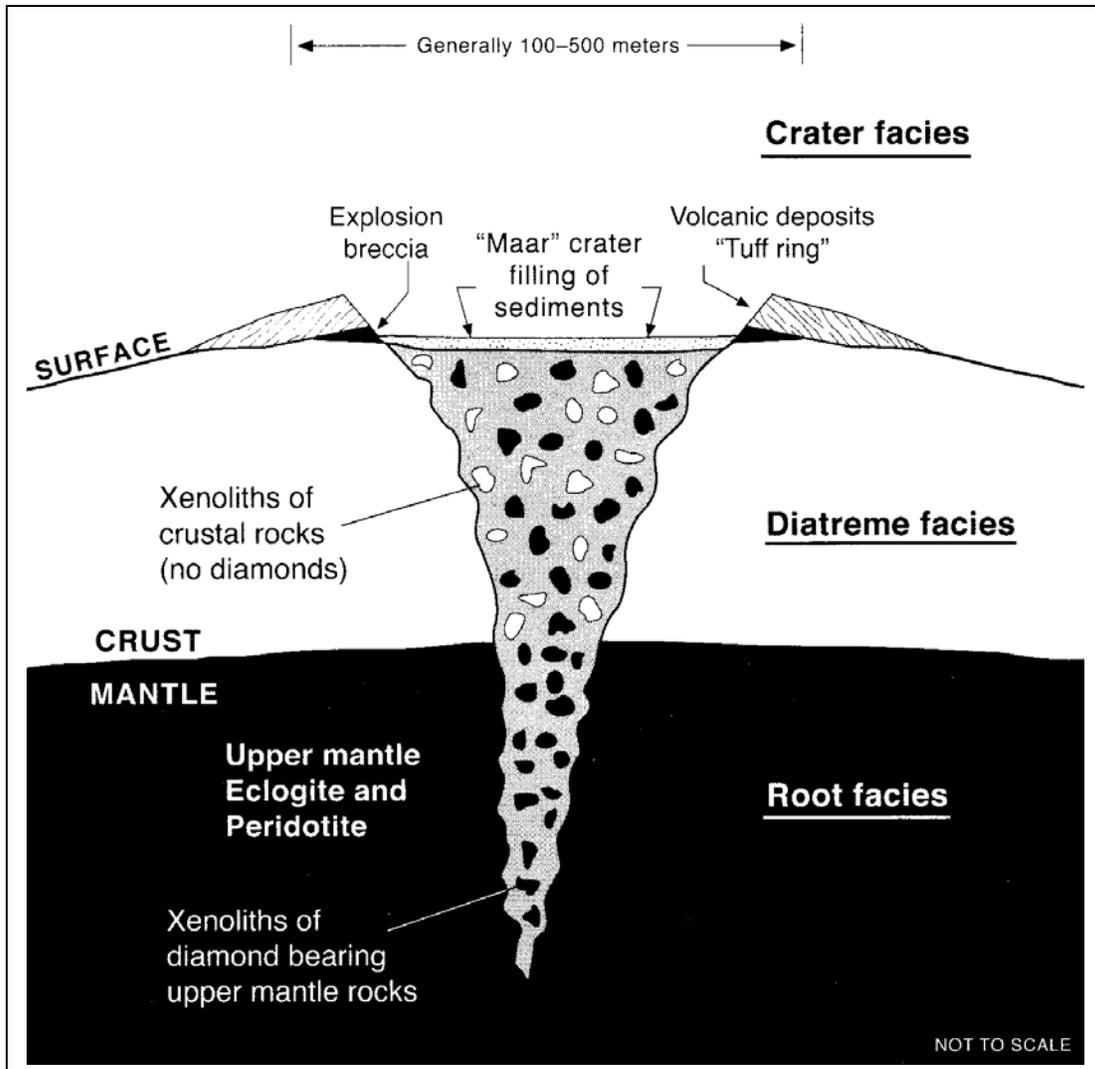


Diagram of an idealized kimberlite intrusion.