The Crystallisation and Occurrence of Diamond

By Anne Padfield

The mineral and gemstone 'Diamond', is the hardest natural substance known to man. Dimorphic with Graphite, the soft mineral form of the native element Carbon (chemical formula 'C'), which is only 1-2 on the Moh's scale of hardness, being easily scratched, Diamond is also the native element Carbon, in a dramatically harder form, scoring 10, the maximum on the Moh's scale. It can only be scratched by other diamonds (Macdonald, Orbis, 1988).

Diamond is a solid, crystalline substance, with homogenous physical properties and a distinct symmetrical crystal structure, whereby its atoms are arranged in a particular cubic design, which repeats itself over and over again, covalently bonding with four other Carbon atoms, to build up a compact three dimensional network, which forms the crystal (Macdonald, Orbis, I 988)(See Figure 1). The resultant chemical bond is extremely strong and gives diamond its extreme hardness(Macdonald, Orbis, 1988). Although Diamonds belong to the cubic or isometric crystal system, they usually appear as octahedral or dodecahedral, rounded edged crystals and less often as cubes (Macdonald, Orbis, 1988). They can occur in many colours, yellow, brown, grey, orange, pink, green, red, blue, white and black, or they can be colourless. Black imperfect diamonds are usually termed 'Bort'. 'Ballas' is a drusy mass of tiny crystals and 'Carbonado' is an opaque black/grey variety, lacking cleavage (Treasures of The Earth, 1998).

The lustre of diamonds is usually adamantine, but can be greasy or dull (Macdonald, Orbis, 1988). They disperse light entering them strongly, by refraction, the superb brilliance of which is measured by their Refractive Index, which is 2.417, which is very high (Sofianides & Harlow, 1990). Diamonds do not dissolve in either acids or alkalis (Macdonald, Orbis, 1988), but if heated to 800 degrees centigrade in oxygen, will burn, giving off Carbon Dioxide (Encarta, 1996). Sometimes diamonds fluoresce, blue, pink, yellow or green, under ultra-violet light (Macdonald, Orbis, 1988), or exhibit a blue to green luminescence (Duda & Rejl, 1986). The Specific Gravity of diamond is *3.52;* that is, it is 3.52 times heavier than an equal volume of water (Kourimsky, 1977).

Better diamonds are transparent, but they can also be opaque (Schumann, 1992). They cleave perfectly along octahedral cleavage planes, on faces with the Miller Indices 111, within the atomic structure of the crystals, but they are fragile and brittle and do not fracture neatly, displaying a conchoidal (shell-like) fracture pattern (Schumann, 1992). When powdered all diamonds are white, irrespective of their unpowdered colour, they are said to have a white 'streak' (0uda & RejI, 1986). Sometimes the crystal faces are striated (Bauer, 1987) and often, two crystals are joined together in a phenonomen known as 'twinning' (Clark, 1989).

Diamonds are found in rare and unusual volcanic, ultramafic rocks called Kimberlites. This name was given to the diamond bearing, olivine rich, porphyritic mica peridotites, of Kimberley, South Africa and thence to all such rocks of similar composition containing diamonds (Middlemost, 1985). Alkaline and usually containing potassium, olivine, phiogopite, pyrope garnet and chrome diopside, Kimberlites contam minerals that were formed at very high pressures (Middlemost, 1985). Diamonds form at pressures in excess of 50,000 atmospheres (Sofianides & Harlow, 1990). This means that diamonds form at depths of more than 90 miles (150 km), deep in the Earth's upper mantle (Sofianides & Harlow, 1990). The Kimberlites form in pipe like intrusions or vertical volcanic vents, dykes, sills and diatremes, generally occurring in clusters or swarms (Middlemost, 1985)(See Figure 2). The diamond bearing kimberlitic magma needs to ascend from the mantle, through the lithosphere, at speeds in excess of 740 mph, in order for the earlier formed diamond crystals, to be transported intact (Sofianides & Harlow, 1990). The ultrabasic kimberlite magma, probably follows and forces open fractures and faults in the lithosphere to form the pipes (Middlemost, 1985). The diamonds are distributed randomly throughout the magma (O'Donoghue, 1994).

Another rock like Kimberlite, formed 150 to 200 km below the Earth's surface and ~ diamonds, is Olivine Lamproite, which is a sub-volcanic, extrusive, igneous rock, similar to Lamprophyre (Middlemost, 1985). Lamproites are generally rich in potassium, magnesium and leucite, but it is the rarer, olivine rich varieties that are diamondiferous. Lamproites are usually found to occur with kimberlites and it is thought that their composition changed on their journey up through the lithosphere (Middlemost. 1985).

For many years it was thought that diamonds were formed in the magmas, however, there is now evidence that this is not the case. From garnet inclusions diamonds have been dated as being at least 3.2 ga older than their 'Mother stone' kimberlite (Solfianides & Harlow, 1990). So they did not crystallise in the magma in which they are found, the kimberlite simply transports the diamonds. Diamonds probably form at convergent tectonic plate boundary subduction zones, when the basaltic ocean crust, together with carbonaceous sediments, is drawn into the mantle and subjected to tremendous heat and pressure (Sofianides & Harlow, 1990). Most diamond bearing rocks are found in old cratonic areas (Middlemost, 1985).

Erosion of the top surface of the pipes and tectonic movements bring the diamonds closer to the surface, where they can be extracted by mining, or are washed away into rivers or the sea, or remain in the soil (Treasures of the Earth, 1998). River and beach gravel, placer and alluvial deposits are the alternative source of diamonds and there are even sophisticated survey ships that search for diamonds on the sea bed (Treasures of the Earth, 1998). The hardness an durability of the diamonds, prevents them from being fragmented and their density makes them sink quickly in water. If they are polished by the river or sea for many years, they may become rounded and look like any other worthless pebble and so be accidentally disregarded. However, many deposits were discovered while searching for placer gold (Sofianides & Harlow, 1990). Consolidated gravel's may form conglomerates, which can be another source of diamonds. Diamonds may also be found in high grade, regionally metamorphosed schists (Hochleitner, 1994) and occasionally in meteorites, especially in Arizona, USA (Duda & RejI, 1990).

Diamonds have been found for hundreds of years in alluvial deposits and the first and most well known of these, were those of Golconda, India, which yielded large and valuable gems, which became the property of the Indian Princes and Maharajahs (Kourimsky, 1977). A famous example is the Koh-I-Nur diamond, weighing 108.9 carats (a carat is 200 milligrams), which is set in the crown of Queen Elizabeth II (Kourimsky, 1977). Other famous Indian diamonds are the Hope diamond, which is blue, 112 carats and is kept in the Smithsonian Institute, Washington D.C., USA and the Regent diamond, 137 carats, in the Louvre, Paris (Treasures of the Earth, 1998).

In 1727, diamonds were discovered in compacted gravel's, in Brazil at Minas Gerais and Bahia. Later, in 1866, a diamond weighing 21.75 carats was discovered near Hopetown, South Africa, by a young boy. The mining of the diamond gravel's of the region soon followed and in 1870, the first pipes containing diamonds were found (Boegel, 1976). The largest diamond ever found, the Cullinan diamond, came from South Africa. It weighed 3106 carats and came from the Premier mine, Pretoria (treasures of the Earth, 1998). 104 gemstones were cut from it (Duda & RejI, 1990), the largest being the 530 carat, Star of Africa, which is displayed in the Tower of London, being part of the Crown Jewels of Britain (treasures of the Earth, 1998).

Eighty percent of diamonds are produced by the seven most important diamond producing countries, which are, Angola, Western Australia, Botswana, Namibia, Russia, South Africa and Zaire. Diamonds are also found in Sierra Leone, Ghana, USA, Venezuela and Borneo (Treasures of the Earth, 1998). The Siberian Mir pipe is one of the largest in the World (O'Donoghue, 1994). North western Australia is currently the World's biggest producer. It's mines at the Argyle and Ellendale, olivine lamproite diatremes, contain 50% of the World's diamond reserves (Sofianides 7 Harlow, 1990). Whilst sampling, between late 1979 and mid 1982, 47.56 kg (237,794 carats) of diamonds were extracted from 46,257 tonnes of olivine lamproite (Middlemost, 1985). Zaire ranks the World's second biggest
producer and Botswana also ranks highly, because 50% of it's diamonds are of gem cutting quality, as are those of 90 % of the beach placer deposits of Namibia (Sofianides & Harlow, 1990).

Diamonds can be used in two main ways, as gemstones and in industry. Colourless, flawless diamonds, are the most highly prized, but coloured diamonds, called 'fancies', are also highly sort after. Their colouration comes from impurities of otber substances, within their atomic structure. Diamonds are usually cut into the 'Brilliant' cut, which has 58 facets, 33 above the girdle (visible top of stone) and 25 below and utilises the perfect cleavage of the crystal to tull extent, dispersing the light to perfection, giving the cut stone it's 'fire' (Treasures of the Earth, 1998).

The majority of flawed or unattractively coloured stones are used as abrasives, because of their extreme hardness. They are electroplated to the tops of drill bits and on diamond edged circular saws, as they will cut through any other natural substance (Treasures of the Earth, 1998). Industrial diamonds are called 'borts'. Gnly diamond will cut another diamond. As diamond is so useful and valuable, synthetic diamonds are made by subjecting graphite to pressures of at least 100,000 atmospheres and heating it to 3,000 degrees centigrade or more. The General Electric Co., New York. USA, first accomplished this technique (Treasures of the Earth, 1998). Synthetic diamonds are mostly used for making grinding wheels for tungsten carbide tools (Treasures of the Earth, 1998).

Diamonds are also useful to scientists, due to their frequent inclusions of other minerals or elements which can be in solid, liquid or gaseous form. These inclusions formed at the same time as the diamonds, I tell scientists a great deal about the nature of the Earth's mantle, however, they are a bane to lapidarists, as the quality of the gem is impaired (Treasures of the Earth, 1998).

Diamonds are the most beautiful and dazzling of precious stones. They belong to the cubic system and have a very strong structure, which makes them the hardest known natural substance and as such they are used extensively in industry for cutting, grinding and as abrasives. They come in many colours and are heavy so that they are emplaced in alluvial deposits after being weathered from their parent rock. They form under enormous pressures and temperatures at great depth. They have perfect cleavage, which enables the best of them to be faceted into fine gem stones. Diamonds are found all over the world, but the most important present source is Australia. Diamonds will continue to be very special gems, by symbolising in western Society, everlasting love and having an allure that is irresistible. Diamonds are and always will be, **forever.**

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THE BIG BANG

How old is 'time'?
Is 'time' as old as God?
If there is no God, does time exist?
Did time begin or has it always been?
Did time begin with the 'Big Bang'?

From nothing came something,
Exploding, expanding,
Elemental, atomic,
Dynamic, bombastic.

Electrons joined protons and neutrons,
Made atoms, which collided and coagulated,
By weight differentiated.

With density, came gravity,
And exuberant electricity,
The molecular and the secular
Or, was it the divine, the beginning of time.

With immeasurable velocity,
The Universe evolved.
With incalculable dimensions
Stella systems far and wide.
The astronomical arrangement
Arithmetically assigned.
starry space, celestial,
Infinite and beautiful.
A vast expanse of galaxies,
Incredible, intangible.

Was the Astral evolution essentially ethereal?
Or was it by chance
That 'time' began,
With the 'Almighty', asto - physical
Cosmos creating, 'BIG BANG'

by **Anne M Padfield.**

The More things Change, etc

"We trained hard but it seemed every time we were beginning to form into teams, we would be reorganised. I was to learn later in life that we tend to meet every situation by reorganising, and a wonderful method it is for creating the illusion of progress while producing confusion, inefficiency and demoralisation.

Caius Petronius. 65 A.D.