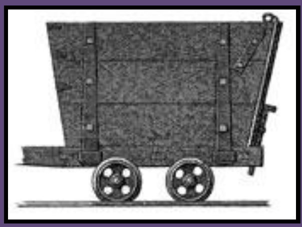
Gem Hunter – The Prospector's Newsletter



Vol 3, No 1, Jan-Feb. 2011 *Newsletter from the GemHunter*

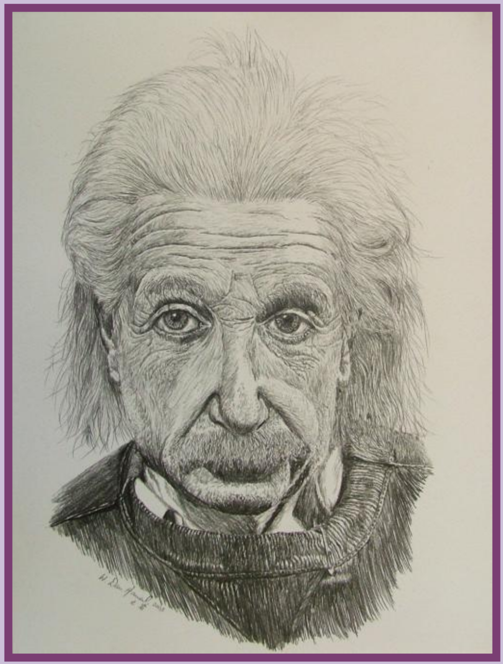
HAPPY NEW YEAR

DIAMONDS – Origin & Occurrence

So where does diamond come from? A jewelry store? Yes; but before the jewelry store, they have a long and interesting journey.

Some diamonds actually come from the stars. Carbon, the principal ingredient for diamond, is created during nuclear fusion in stars then disseminated in nebula during supernovae explosions. Considerable carbon was also created during the Big Bang (13 billion years ago) when the universe erupted from a ball of energy.

Alien searching for diamonds among the stars (right), while one of our favorite physicists ponders this – sketches by the author.

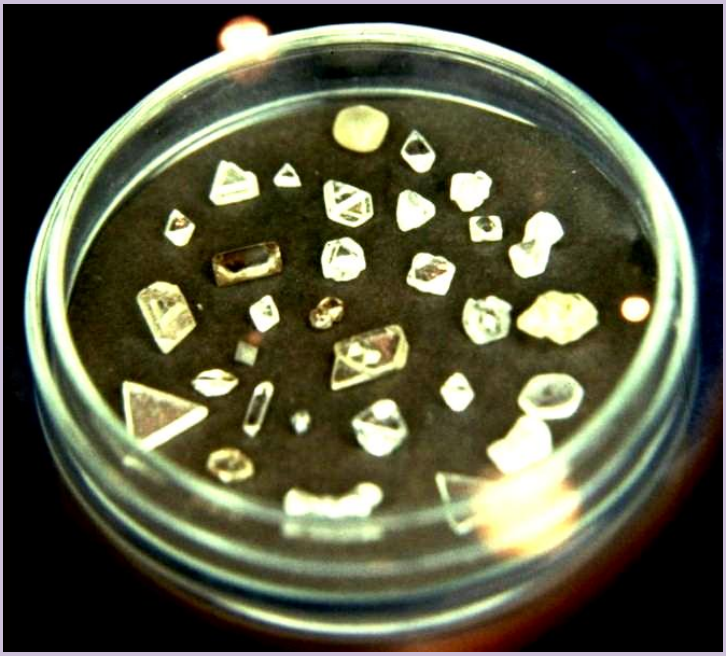


Some meteorites have diamond and/or its polymorphs. Others arrived at the earth's surface from the opposite direction, from the upper mantle (90 to 120 miles depth) via extremely rare volcanic eruptions. Some diamonds may even have originated near the earth's core-mantle boundary and then followed convection cells to the upper mantle based on the presence of an unusual garnet known as *majorite* found as a rare mineral inclusion in some diamonds (Erlich and Hausel, 2002).

When subjected to incredible pressures and temperatures, carbon will form diamond. To get the pressures required to form diamond, we would need the weight of a 90-mile high column of rock to sit on a piece of carbon. If we to take pencil lead, or some unsuspecting insect or plant, and stack a pile of rocks as high as 400 empire state buildings (filled completely with concrete) on top – whoosh – we have tiny diamonds instead of a pencil or insect. This is why diamonds are so rare – it takes rare conditions to form them and very rare conditions to get them to the earth's surface so we can mine them. The deepest mines on earth (Witwatersrand gold mines in South Africa) have only reached depths of around 12,600 feet. That may sound like a lot, and it is; but it is 462,200 feet too shallow to reach diamonds in the mantle. So, it is obvious that we are not going to dig deep enough to reach these diamond ore shoots, so they somehow need to come to us. And since diamond is unstable at the earth's surface where atmospheric pressures are insignificant compared to pressures at depth, these gems must come to the surface at a very fast rate; otherwise, they will revert to pencil lead (graphite).

One way to get these gems to the surface and into your local Tiffany's is by using a geological elevator. This elevator, or what geologists call kimberlite, lamproite or lamprophyre magma, is an extremely rare magma that forms at great depth in the mantle where the diamonds occur. Diamond may also be thrust up from the mantle, but we'll just focus on the magmas for now (Hausel, 1996).

Since diamonds are unstable at the earth's surface, when the gemstones rise from their cozy beds in the upper mantle, they have the tendency to resorb (melt) or burn, and the only way they are preserved is by the hot magmas rising and cooling very fast before the diamonds can be destroyed. It is not difficult to burn a diamond on the earth's surface – I burned one back in 1985-86 in a Bunsen burner flame as an experiment, and it only took about a minute of heating.



Resorbed (odd-shaped) diamond crystals from Argyle, Australia. These diamonds all partially resorbed in the hot magma before reaching the earth's surface (photo by the author).

The primary host rocks for terrestrial diamond are pieces of the earth's mantle known as peridotite and eclogite. Some of these can be very rich in diamonds. I saw one eclogite sample from the Sloan 1 kimberlite in Colorado that had ~20% diamond. To get these rich primary rocks to the surface, they are carried in magmas that begin their journey in the upper mantle.

Diamondiferous peridotite nodule from the Aultman kimberlite in Wyoming (photo by the author).

Enter kimberlite magma. When kimberlite magma begins its initial migration, it is under tremendous pressure and tends to pick up many diamonds along with pieces of diamond-rich eclogite and peridotite. Some of these rocks will disaggregate on the journey to the earth's surface and disseminate their diamond load throughout the kimberlite magma. And if they really hurry, many of the diamonds will be preserved by the time they reach the earth's surface.

Characteristic depression and vegetation anomaly over a the Maxwell kimberlite in Colorado (photo by the author).

At the surface, the kimberlite magma will erupt to produce a maar-like volcano (depression) that does not have the typical cone we are used to seeing associated with volcanoes. The gas in the kimberlite being under tremendous pressure will erupt from the volcano at speeds of 1 to 3 times the speed of sound. Now that is a volcano! With such speeds, the magma fragments rocks all the way from the mantle to the surface and produces a breccia pipe (maar).

Right – exposed high wall at the Kelsey Lake diamond mine, Colorado. Note the large number of white-colored & angular blocks of rock in the bluish-gray kimberlite matrix (photo by the author). Find this mine on GoogleEarth by searching for 'Kelsey Lake, Livermore, CO'.

The erupting kimberlite magma will release considerable gas while some of the gas (water vapor and carbon dioxide) reacts with the magma to produce mica and calcite. But most of the gas is erupted into the atmosphere.

Being under pressure, when kimberlite erupts, the associated gas expands and its temperature will be lowered to freezing– so if you are standing next to this volcano, you will need to wear a coat, mittens and stocking hat. And if the EPA gets wind of this, erupting kimberlite volcanoes will be taxed. Yep, the EPA, Obama and Gore will be searching for their carbon credits.

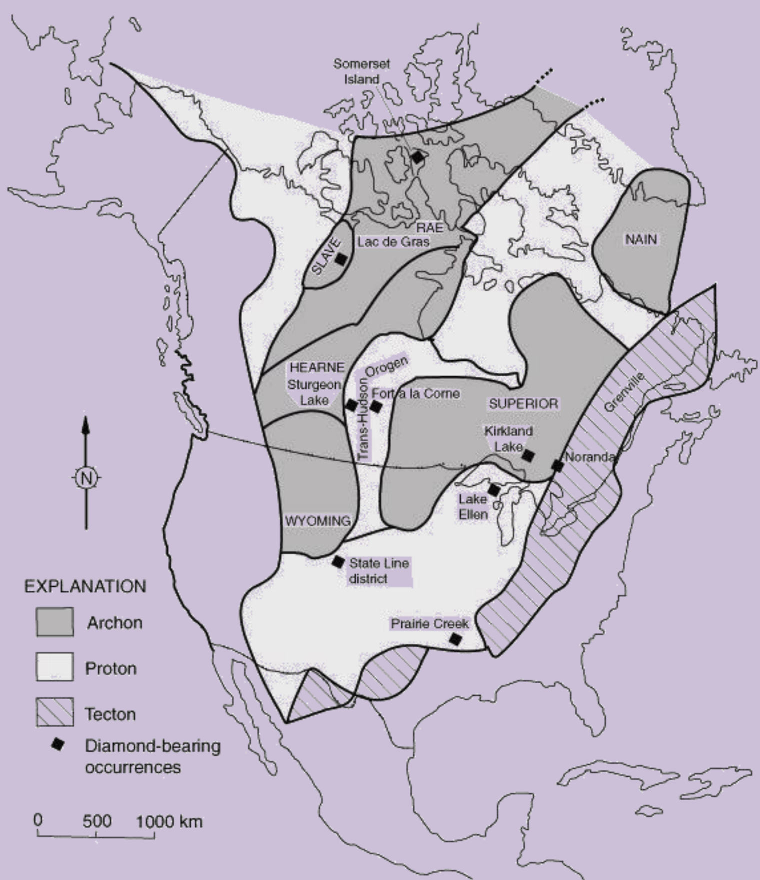
Carbon dioxide is basically plant food, but the EPA now lists this plant food as a pollutant of global warming (*Isn't that a kick? Anyone feeling the effects of global warming today? At 3 pm on New Year's*

Eve, the wind-chill in Laramie, Wyoming is -32^{o}F, just a little colder than Yellowknife, Canada and a lot colder than Nome, Alaska. In good O' hot Gilbert, Arizona, the wind-chill is 38^{o}F – it looks to me like we could use some global warming). Wow, imagine a world without plants. If you remember your high-school biology, plants absorb carbon dioxide and give off oxygen. We in turn, absorb oxygen and give of carbon dioxide – it's the natural cycle of life and the government claims it is not only polluting, but they now want to tax it. What next, H_2O?

There are literally thousands of known kimberlites and many hundreds of lamproites and lamprophyres but only a handful has commercial amounts of diamond. One estimate made years ago suggested that <1% of all kimberlites are commercially mineralized in diamond (Lampietti and Sutherland, 1978). Although, a few thousand kimberlites have been discovered since 1978, that statistic still remains essentially valid. Commercially minable diamond deposits are very rare. They are as rare as Congressmen who pay taxes.

Diamondiferous kimberlites and lamproites are essentially restricted to cratons and cratonized terrains. The easiest way to think of a craton is to think of them as the very old and ancient continental cores – or rock outcrops that are >1.5 billion years old. Some of the oldest parts of these continental cores are referred to as Archons: these consist of rocks >2.5 billion years old. So if you were to start prospecting for diamond-rich kimberlite volcanoes, your chance of finding one will be much greater in these very old Archons, since essentially every commercial diamond-rich kimberlite that has been mined in history, has been located in these areas. But there are exceptions, such as the diamond-bearing lamproites at Argyle Australia, Murfreesboro, Arkansas, Ellendale, Australia, and Golconda, India. These are located in the younger Proterozoic age continental cores (1.5 to 2.5 billion years old) (Erlich and Hausel, 2002).

So, let's take all of the soil, dirt and younger rocks in North America and just strip them off, so we can see where all of these very old continental core rocks are found and then if you want to prospect for diamonds, go to those areas and hopefully you will find a couple of billion dollars in diamonds.



Right - by removing soil cover and rocks <600 million years old from North America, the continental core is clearly seen. In this illustration, one can see areas of high favorability for diamondiferous kimberlite and lamproite known as Archons. Diamond mines and diamond-rich kimberlites in Canada are mostly in kimberlite within Archons. These include Ekati, Diavik, Jericho,

Snap Lake, Gahcho Kue (Kennedy Lake) and Victor (Hausel, 2006, 2008). The diamond-rich kimberlites at Ekati and Diavik are in the Slave Province. To visit this area, search ‘Ekati airport, Canada’ (64°43’22.73”N; 110°36’54.11W) on GoogleEarth, and you will fly to the open pit mines at Lac de Gras. While there, look for circular lakes or nearly circular lakes that appear to line up with others: >120 diamondiferous kimberlites have been found in this immediate area so lakes often sit on kimberlite! Now search for ‘Diavik airport, Canada’ to visit a nearby diamond mine.

Good prospects have also been identified in kimberlite, lamproite and lamprophyre in Proterozoic terrains referred to as ‘Protons’ by diamond exploration geologists. The Prairie Creek (Murfreesboro, Arkansas) lamproite and diamond-bearing kimberlites in Colorado, Wyoming and Michigan are in Protons. All of these have lower diamond ore grades and smaller diamonds on average. However, the diamond-bearing lamproite at Argyle, Australia, is rich in diamonds (fly to ‘Argyle airport, Australia’ with GoogleEarth to visit this mine).

More than 2000 kimberlites have been found in Canada. One should expect similar discoveries in Wyoming and Montana, but for some reason, politicians and government bureaucracies tend to stymie exploration. For instance, both the forest service and bureau of land management often hinder exploration. The forest service in particular has a bad reputation when it comes to exploration and mining: the agency often submits large land withdrawals whenever mineral discoveries are made.

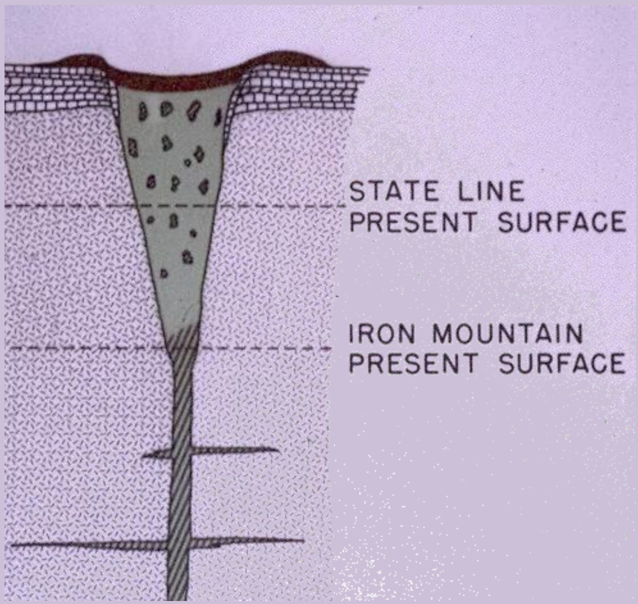
The major Archean (continental core) provinces are in all capital letters (from Levinson and others, 1992). These Archons offer the highest potential for discovery of commercial diamond deposits (Hausel, 1998).

There are also diamondiferous host rocks that are considered to be unconventional by geologists. Some of these have been identified in cratons as well as outside of the continental cores within tectonically active regions along the margins of cratons (Hausel, 1996). Because very high grade diamond ores have been detected in some of these, unconventional commercial host rocks are anticipated to be found in the future (Erlich and Hausel, 2002). Presently, diamond exploration programs are designed to search for conventional host rocks (i.e., kimberlite and lamproite) or for placers presumably derived from these.

Kimberlite

The majority of diamond mines were developed within kimberlite such as the Wesselton, DeBeers, Kimberley, Bufontein and Dutoitspan and South Africa (fly to *‘Kimberley, South Africa’* on *GoogleEarth* and look within the city for circular open pit mines – these include some of the richest diamond deposits ever found). Diamonds eroded from these kimberlites produced the richest diamond placers on earth: the diamonds were carried down the Orange River for 500 to 700 miles to the beaches along the west coast of Africa (See *29°39’43’’S; 17°03’15E* on *GoogleEarth* and look for all of the piles and piles of tailings along the west coast of Africa that go on for miles – these are all placer diamond deposits).

Lampietti and Sutherland (1978) reported only about 10% of known kimberlites are mineralized with diamond. This statistic may no longer be valid in that ~50% of kimberlites found in Canada and Wyoming over the last few decades, and as many as 90% in Colorado have yielded diamond. When economic, kimberlites may contain hundreds of millions to billions of dollars in diamonds; thus kimberlite should be a priority target in any exploration program for mining companies and for prospectors in general. Diamonds are worth much more than gold!



Cross-section of a kimberlite pipe from Colorado and Wyoming. The vertical scale of this cartoon would be about 5,000 to 10,000 feet, thus in the State Line district of Colorado and Wyoming about 2,000 to 3,000 feet of the upper pipe has been eroded. In other words, the richest part of these diamond pipes have been removed and the diamond load is now somewhere downstream from the State Line and diamonds likely have been scattered down the Poudre River drainage and tributaries to LaPorte, Fort Collins, Denver and beyond. With all of the sand and gravel that has been mined along this drainage near Fort Collins, it is likely that a fortune in diamonds went unrecognized and thrown away.

Kimberlites are carbonated alkali peridotites that exsolve CO_2 during ascent to the surface from the earth's upper mantle. The release of the CO_2 gas under pressure (*the same gas that produces carbonation in soda pop, and the same gas required by plants to live recently declared toxic by the EPA*) results in incredible eruptions producing what are known as diatremes of intensely brecciated kimberlite with rounded xenoliths and cognate peridotite and eclogite nodules. The diatremes form sub-vertical to vertical pipes that taper down at depth to form steeply inclined cylindrical bodies.

In cross-section these have carat-shape. The average angle of inclination of the walls of various diatreme pipes in the Kimberley region of South Africa (Wesselton, DeBeers, Kimberley and Dutoitspan) is 82° to 85°. Ideally, the pipes have rounded to ellipsoidal horizontal cross sections filled with kimberlitic tuff or tuff-breccia. Many taper from the surface to depths of 1 to 1.5 miles where they pinch down to narrow root zones emanating from a feeder dike. The kimberlite rock itself will have so much calcium carbonate, that it will fizz like a soda pop if you place a drop of dilute 10% hydrochloric acid on the rock.

Kimberlite sample from the Sloan 2 kimberlite in Colorado – note the large chromian diopside gemstone in the matrix. Kimberlites may have a variety of gemstones besides diamond.

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The Kimberley pipe contracted sharply at depth. At the lowest level of mining (3,465 feet), it was no longer pipe-shaped but rather had the appearance of three intersecting dikes (Kennedy and Nordlie 1968). Combined with the estimated 5,100 feet (1,600 m) of erosion since the time of emplacement, the depth to the original point of expansion was probably 1.5 miles (2.4 km).

Kimberlitic magmas are interpreted to originate from depths as great as 120 miles and travel to the Earth's surface in a matter of hours (O'Hara and others, 1971). The magma rises rapidly, possibly 5 to 20 miles/hour in order to transport high-density ultramafic xenoliths and cognate nodules (peridotite and eclogite). Within the last few miles of the surface, emplacement rates increase dramatically to several hundred miles per hour. Such velocities could bring diamonds from the mantle to the surface in less than a day. McGretchin (1968) estimated that the speed of the fluidized kimberlite near the surface increased to as much as 870 miles/hour, or about the speed of sound (Mach 1). Some estimates have even suggested kimberlite emplacement at the Earth's surface may have achieved velocities exceeding Mach 3 (Hughes 1982)!

The temperature of the magma at the point of eruption is relatively cool. Watson (1967) indicated that the magma temperature was less than 600°C based of the coking effects on coal intruded by kimberlite. A low temperature of emplacement is also supported by the absence of any visible thermal effects on country rock adjacent to most kimberlite contacts. Davidson (1967) suggested the temperature of emplacement may have been as low as 200°C based on the retention of argon. Hughes (1982) pointed out that the near-surface temperatures of the gas-charged kimberlite melt may be more on the order of 0°C (32^{o}F) owing to the adiabatic expansion of CO_2 gas as kimberlite erupts at the surface. So this is most likely the only volcano you can stand next to and catch a cold when it erupts.

Exposed contact of one of the Schaffer diamondiferous kimberlites, Wyoming, showing a knife sharp contact between the kimberlite (left) and granite (right), (photo by the author).

Kimberlites typically transport xenoliths and xenocrysts to the surface. Many are derived from mantle depths and some form a distinct suite of minerals that are referred to as kimberlitic indicator minerals. The traditional indicator minerals used to explore for kimberlite include pyrope garnet, chromian diopside, chromian enstatite, picroilmenite, chromite, and diamond.

Summary

Now that you know where diamonds come from, we'll discuss some of the localities in the next issue of the GemHunter's Newsletter. By the way – I wish you all a very Happy and Prosperous New Year - talk to you in 2011.

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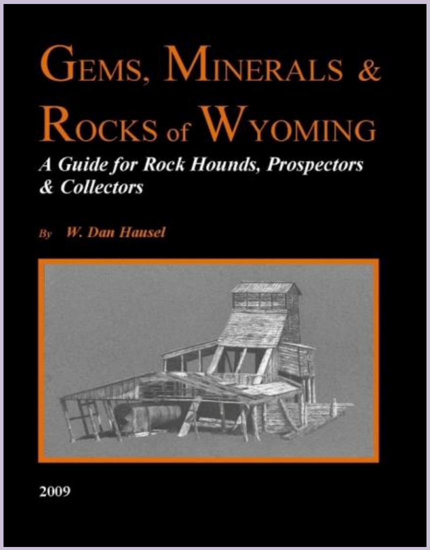
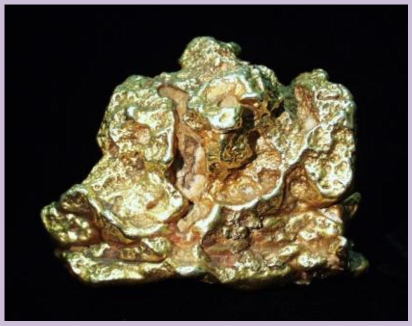
BOOKS



Gems, Minerals and Rocks of Wyoming – A Guide for Rock Hounds, Prospectors and Collectors is available from Amazon: or order it from your local bookseller.



In 2011, watch for: ***'GOLD: A Prospector's & Geologist's Guide to Finding Precious Metals in Wyoming*.** A book on how to find gold and other precious metals and where to find them.

Over 3 decades, I found two (possibly 3) major gold deposits and hundreds of anomalies. I enjoyed finding them – now it's up to you to explore and mine them.

LINKS

webs

Gem Hunter
Consulting
Finding Diamonds
Gold

Blogs

How to find Gemstones - http://gemstonehunter.blogspot.com/
Books on Gemstones - http://wygemstones.blogspot.com/
Ruby & Sapphire - http://WyRuby.blogspot.com
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UPCOMING

Recently I was asked about the books I'm writing. The order that these are being completed for now:
(1) Gold – A Prospector's & Geologist's Guide to Finding Precious Metals in Wyoming,
(2) Gold Deposits of the West,
(3) A Layman's Guide to Martial Arts,
(4) Diamond Deposits – A Prospector's Guide.
(5) Colored Gemstone Deposits – A prospector's Guide;
(6) Gemstone Deposits of the World and their Geology, and
(7) Mountain of Gold.

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