Prospecting for Diamonds in Kimberlite

January 2014 by W. Dan Hausel

Kimberlite is just one of several rock types that contain diamond. Even so, only two rock types contain commercial amounts of diamonds—kimberlite and olivine lamproite (as well as placers derived from the erosion of these rock types). Commercial amounts of diamonds will likely be discovered in other rock types in the future. These were discussed in a 1998 book, *Diamonds and Mantle Source Rocks in the Wyoming Craton with a Discussion of Other US Occurrences*, and a 2002 book entitled, *Diamond Deposits.* Both books can be found by searching the author's name on Amazon. To date, diamonds have been found in many states in the US—notably Arkansas, California, Colorado, Wyoming and Michigan.

Most people assume kimberlite was discovered in South Africa, where it received its namesake at the diamond mines of Kimberley. Search either Google Earth or Flash Earth for "Big Hole Kimberley, South Africa" to see the original mine and also look three to five miles to the southeast at the famous Bulfontein, DuToitspan and

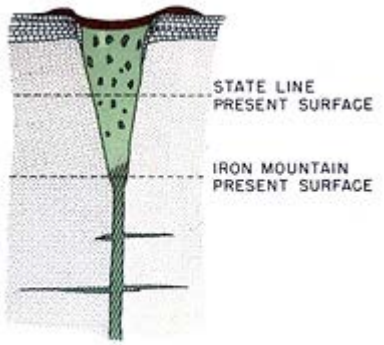
The Sloan 5 kimberlite in Colorado is a circular diamond pipe, a typical vegetation anomaly and no trees in blue ground.

Wesselton diamond mines. After you learn a little about the characteristics of kimberlite pipes, you will want to revisit the region around Kimberley because there are anomalies that are

likely unmined and possibly undiscovered kimberlites.

Kimberlite was actually discovered in the US in the Ithaca, Manheim and Syracuse regions of New York in 1837 where it was described as mica peridotite. Years later, kimberlite was found in Kentucky in 1884 in the chigger infested areas of Ison Creek and Hamilton Branch, two years prior to mica peridotite at Kimberley, South Africa being branded “kimberlite” by Carvil Lewis. The first diamonds in South Africa were found in 1867, but even this was not the first diamond discovery. Diamonds were found and mined in the Godavari, Krishna and Penner placers in India. It is thought diamonds were found in these placers as much as 3,000 to 6,000 years ago. Diamond was even mentioned in the *Holy Bible.* The Kimberley discovery was a first for commercial diamonds found in a host rock.

Kimberlite is very difficult for geologists to find, let alone prospectors and rock hounds. This is because kimberlite is rarely exposed on the surface and few people know how to identify the rock. When exposed, the rock is subjected to weathering, which breaks down the rock into a gray-blue montmorillonite clay that yields soil that has been given the descriptive term “blue ground” by South African diamond miners. Kimberlite is further camouflaged due to low resistance to erosion compared to many rocks that it intrudes. Most surrounding country rocks are relatively resistant to erosion, but when they erode, they tend to disaggregate and mix with the blue ground further burying evidence of the softer kimberlite. And because of the relatively different chemistry of kimberlitic blue-ground soils compared to soils of most country rocks, the blue ground will often have subtle vegetation anomalies that can only be picked out by a trained eye.



Cross-section of kimberlite in Colorado and Wyoming.

Chemically, kimberlite has relatively high potassium, magnesium and chromium and low silica, whereas most country rocks intruded by kimberlite have high silica, low magnesium, and no chromium. The abundant clay in blue ground also appears to choke most trees – so trees may be rare in blue ground although they will grow in the kimberlite rock.

Another complication for prospecting is the very small surface area of these igneous intrusions. Kimberlites erupt as small maar-diatreme volcanoes referred to as “pipes” that flare vertically. A generalized cross-section

of a pipe would appear like a carrot. These pipes rise at depth from a feeder dike-sill complex at a few thousand feet beneath the surface. The size of the kimberlite intrusives is very small ranging from tiny dikes and sills of 2 to 12 feet wide to pipes of 200 to 5,000 feet in diameter. Most are considerably smaller than 5,000 feet.

But even with all of these complications, there are tools and methods used by geologists that can be learned by prospectors to find their own diamond deposit. But be forewarned—it takes time and effort and cannot be learned overnight. Even so, when found, the rewards can be enormous: many faceted diamonds sell for many times an equivalent weight in gold. As an example, one of the highest prices per carat for a diamond was paid for a rare 24.78-carat pink diamond sold at auction for $46 million in 2010 (US$1.86 million per carat). This would be valued at 192 times more than an equivalent weight in gold! The faceted price of diamond is dramatically higher than the price of raw diamond. Raw diamonds are valued 10 to 100 times less than a cut diamond. So if you are finding diamonds, you might want to take up faceting.

When prospecting for kimberlite, it is important not only to learn what the rock looks like, but also learn about its geomorphic characteristics. Since kimberlite erupts as small, explosive pipes, they do not have a typical volcanic cone associated with most other volcanoes. Instead, they produce a circular depression that may look similar to an impact crater. Some depressions are so distinct they were actually misidentified as impact craters in the past, such as the Winkler Crater (39°29’25”N; 96°49’14”W) in Kansas. This kimberlite in Riley County was initially classified as an impact crater until Dr. Doug Brookins investigated the anomaly and found the crater to be filled with kimberlite breccia. In the late 1970s to early 1980s, a mining company recovered samples from the kimberlite and may have extracted one tiny diamond.

The Maxwell kimberlite in Colorado appears as a rounded depression similar to an impact feature.

Since kimberlite magma begins its eruptive ascent from great depth in the earth’s mantle, some catastrophic

geological event must have occurred to produce fractures deep enough to allow magma to form at such great depths. Some geologists suggest these fractures are related to actual impact features. Some of the deepest magmas, known as basalt, originated from depths of 35 to 50 miles. Compare this to kimberlite magmas which formed at depths of 90 to 200 miles.

The deep fractures provide conduits for kimberlite. These fractures can be used to find kimberlite. When a kimberlite erupts at the surface, it is localized along a fracture that could be a mile or more in length. The fracture may not be obvious initially, but the more one examines an area, structural control of a kimberlite is usually found. Once the controlling fracture is found, all one needs to do is use a compass bearing and follow the fracture. Kimberlites almost always occur in clusters, so it is likely more than one kimberlite will be found on these fractures. Most of these fractures can be observed on aerial photography such as Google Earth. And

Highwall at the Kelsey Lake diamond mine in Colorado showing distinct exposure of bluish ground in contact with granite. Note the large, fragmented rocks of the kimberlite breccia typical of explosive diatremes.

because of a possible association with impact features, the trends of the fractures that host kimberlite may not all have the same heading—some may occur along radial fractures.

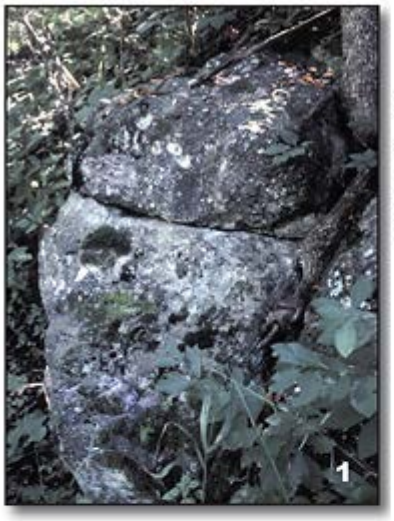
In the Colorado-Wyoming State Line district south of Laramie, a distinct circular structure known as the Virginia-Dale ring dike complex was mapped by David Eggler in 1968. This structure is visible on Google Earth at the coordinates of 40°58’30”N; 105°26’20”W, which is near the center of the 12-mile diameter structure. At an eye altitude of 12 miles, the anomaly is apparent. It is very distinct at higher eye altitudes on Flash Earth. The structure is interpreted as a deeply eroded, Precambrian (about 2.5 billion years old) caldera—but the caldera may be related to an ancient impact site.

Many of the Colorado and Wyoming diamond-bearing kimberlites are located within or adjacent to this

structure. Examination of one radial fracture associated with this feature in Colorado, known as the Chicken Park Fracture, shows a small kimberlite at 40°51’56”N; 105°32’13”W which is seen as a tiny, grassy, nearly circular feature surrounded by trees. If you visit the area on foot, you will find fragments of kimberlite on the surface along with the characteristic blue ground. This tiny kimberlite has diamonds—the largest recovered from the pipe was 2.6 carats.

The Chicken Park fracture is a very prominent lineament with a heading of 47° (N47°E). This fracture can be traced for 3.5 miles. If you have a compass and follow the fracture in the field, you will come across other kimberlite exposures to the south.

To the south, the fracture has been offset to the east just north of the Creedmore Lakes road. From the offset, the same fracture is traced 1.7 miles further south to where it is again offset to the east. It continues another 1.5 miles to the south where it intersects Lake Nokomis. So the entire structure is worth walking and searching for other kimberlites (and just because you don’t see any kimberlite doesn’t mean it isn’t under your feet or under a lake). Many things have been missed and overlooked by others. Good prospectors never assume everything has been found.



Kimberlite samples:

1. Exposure of the Hamilton Branch kimberlite in Kentucky.

2. Most diamond prospectors and geologists assume Kimberlite is green. This weathered kimberlite from the Iron Mountain district is white.

Some circular depressions associated with kimberlite pipes become filled by debris over time making the

depression no longer apparent. Others may be filled with water, producing either a rounded or structurally-controlled pond. A search for “Ekati, Canada” on Google Earth will take you to a group of very diamond-rich circular kimberlites currently being mined. This area has several nearby circular lakes that are likely underlain by kimberlite. In fact, a lake had to be drained before the first pipe could be mined for diamonds.

In the Colorado-Wyoming State Line district, one of the Maxwell kimberlites near the Kelsey Lake diamond mine also has a circular depression that is filled with water certain times of the year. In the vicinity of Lost Lakes (40°50’48”N; 105°31’21”W) north of Red Feather Lakes in Colorado, there are a group of circular depressions filled with water: a few of these have calcium carbonate rich soils that are stained white. Country rocks in the area are granitic with abundant silicate minerals containing no carbonates, so where did all of this calcium carbonate come from?

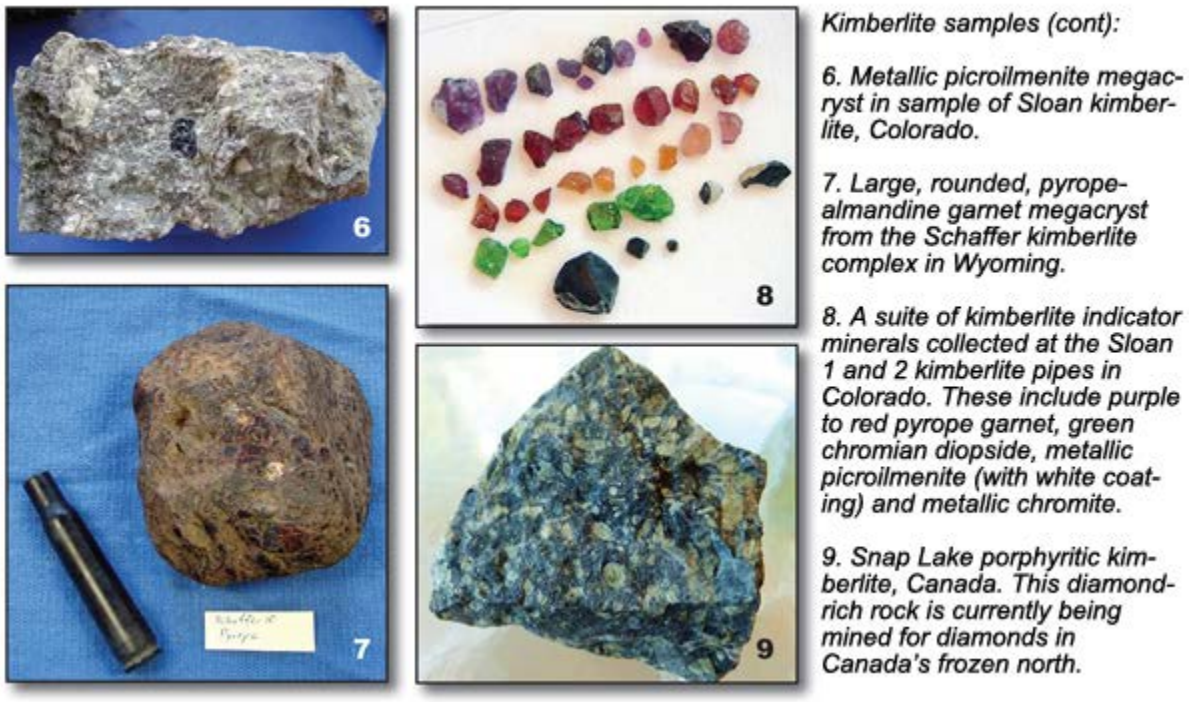
Diamond prospectors search for blue ground containing calcium carbonate in circular or elliptical depressions with vegetation anomalies. If you search Google Earth for “Kelsey Lake, Roosevelt National Forest, Colorado,” this will take you to the former Kelsey Lake diamond mine. While examining the mine, you will see blue ground in some exposures. Note how close the kimberlite is to Fish Creek to the north. This creek should be filled with diamonds, yet the only diamonds ever taken from this creek were during testing by the company that mined Kelsey Lake— they recovered several diamonds in the creek including a 6.2 carat gemstone.

Kimberlite samples (cont):
3. Sample of kimberlite from the Iron Mountain district, Wyoming. This kimberlite contains numerous pits where minerals have weathered out of the matrix. In the center is a rounded pyrope garnet with a leucoxene reaction rim.
4. Serpentinized kimberlite from Iron Mountain, Wyoming with large pyrope garnet megacryst (megacryst is simply a large crystal).
5. Brownish kimberlite from Wyoming.

Diamonds are so hard they will survive stream transport for miles. In southern Africa, some diamonds mined from the Orange River and coastal beaches along west Africa are interpreted to have originated from the Kimberley region 400 to 500 miles away. So, if you trace the drainages downstream from Kelsey Lake for 400 to 500 miles, you might get some idea of where one might find some placer diamonds in this region of Colorado.

The largest diamond recovered from Kelsey Lake weighed 28.3 carats, but the company also recovered a

diamond fragment that was estimated to have fragmented from a 90-carat diamond. The Kelsey Lake mine closed in 1997, not because it ran out of diamonds; it was only because it ran into greedy lawyers. It was barely



Kimberlite samples (cont):

6. Metallic picroilmenite megacryst in sample of Sloan kimberlite, Colorado.

7. Large, rounded, pyrope-almandine garnet megacryst from the Schaffer kimberlite complex in Wyoming.

8. A suite of kimberlite indicator minerals collected at the Sloan 1 and 2 kimberlite pipes in Colorado. These include purple to red pyrope garnet, green chromian diopside, metallic picroilmenite (with white coating) and metallic chromite.

9. Snap Lake porphyritic kimberlite, Canada. This diamond-rich rock is currently being mined for diamonds in Canada's frozen north.

mined.

Many kimberlites with blue ground have vegetation anomalies. These may include a complete lack of trees in a heavily forested area, while the grass in the kimberlite may stand higher and thicker than nearby grassy areas. The vegetation anomalies are often subtle, but more distinct a few weeks after periods of heavy rain. In the Iron Mountain district of Wyoming, I mapped many kimberlites based on the presence of kimberlite rock, blue ground, and continuous high stands of grass. Kimberlites I mapped in the State Line district had the same type of anomalies. And there was a notable increase in the rattlesnake population over the Iron Mountain kimberlites—I guess diamond backs really do like diamonds!

Soils over kimberlite may be white-gray to very distinctly blue-gray. These soils are very carbonate-rich such that carrying a small, plastic bottle filled with dilute hydrochloric acid is always wise when searching for diamond deposits. The acid will strongly react with the blue ground. But this is also true of limestone, which is very common in many places in the world as well as along the edge of Colorado's and Wyoming's basins. Thus, it helps to know the geology of an area one is searching for diamond deposits.

Are there any diamonds in your area? The author compiled this map in 1998 to show locations of reported diamonds, diamond-bearing host rocks and potential host rocks for diamonds.

Many exposed kimberlite pipes have scattered cobbles, boulders and pebbles of rounded crustal xenoliths (foreign rock fragments) and cognate nodules and megacrysts (mantle derived rock and minerals). In some cases, these may give an erroneous impression of a dry placer. After the first kimberlites were discovered in South Africa, it was thought they were placer deposits because of these rounded rocks. The rocks are actually rounded by the kimberlite magma as it rises to the earth's surface.

The clay in altered kimberlite is conductive because of water content. Using ground geophysical methods, such as electrical resistivity or electromagnetics, kimberlite will yield electrical anomalies. Using this method, we were able to identify many kimberlites in 1980 including one hidden under a few feet of soil.

Not all kimberlites contain diamond, but they do all have what is known as "diamond indicator minerals" or "kimberlitic indicator minerals." These include pyrope garnet, chromian diopside, picroilmenite, and high-magnesium chromite. It takes some time to learn to identify the kimberlitic indicator minerals as it does raw diamond. However, raw diamond can be tested with a very simple tool known as a "diamond tester" that sells from $15 to $200. The kimberlitic indicator minerals are used by diamond prospectors to find kimberlite. By panning active streams, these indicator minerals show up with the black sands in a gold pan, and when identified can be traced upstream and upslope to the source kimberlite.