KANSAS GEOLOGICAL SURVEY
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Kansas Kimberlites

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Introduction

Diamonds occur in only two rock types on earth, kimberlites and lamproites, both rare in Kansas. Kimberlite is unique because it originates over 100 miles (150 km) deep in the earth and travels in a matter of hours to the earth's surface where it forms small volcanic features. In Kansas, kimberlites or kimberlite pipes (so-called because of their pipelike, three-dimensional shape) occur in a restricted, northeast-trending belt in Riley and Marshall counties (fig. 1). These rocks were first discovered in Kansas in the late nineteenth century. Since then, more kimberlites have been found — the last three in the fall of 1999. Thirteen kimberlites have been identified so far, twelve in Riley County and one in Marshall County. Six kimberlites are exposed at the surface; the others are buried under soil up to 25 feet (7.5 m) thick. This circular provides general information about these rare and unusual rocks found in the heartland of the United States. Terms in boldface type are defined at the end of the circular.

What are Kimberlites?

Unlike most of the surface rocks in Kansas, which are sedimentary in origin, kimberlite is an igneous rock, formed from the cooling of molten magma. Igneous rocks are extremely rare in Kansas. Kimberlite is composed of at least 35% olivine, together with other minerals such as mica, serpentine, and calcite (Jackson, 1997). Geologists call it an ultrabasic rock, which means it does not contain any quartz or feldspar, the two most common rock-forming minerals. Olivine, the main mineral constituent of the rock, is an olive-green, grayish green, or brown mineral made up of magnesium, iron, and silica. In 1888, the name kimberlite was proposed for this particular rock, based upon the occurrence of these rocks in the vicinity of Kimberley, South Africa.

Large volumes of an olivine-rich rock type called peridotite occur at great depths in the earth in a layer called the mantle. At these depths (100–135 miles or 150–200 km), the combined temperature and pressure is high enough to partially melt some of the peridotite. If volatile gases, such as carbon dioxide and water, are present, they may propel the molten peridotite upwards, forming a kimberlite magma. As the hot kimberlite magma rises slowly upward into regions of lower temperature and pressure in the upper mantle and overlying crust, minerals start to crystallize and the volatile gases expand and exert increasingly higher pressures on the surrounding rocks, eventually breaking some of the surrounding rock and incorporating it into the magma. Closer to the earth's surface the internal pressures of the magma and volatile gases become so great that the kimberlite becomes explosive (fig. 2). Kimberlite magma can rise toward the surface at speeds estimated at up to 400 meters (1,200 feet) per second, ripping up more and more pieces from the surrounding rock, which gives the kimberlite its characteristic texture (fig. 3).

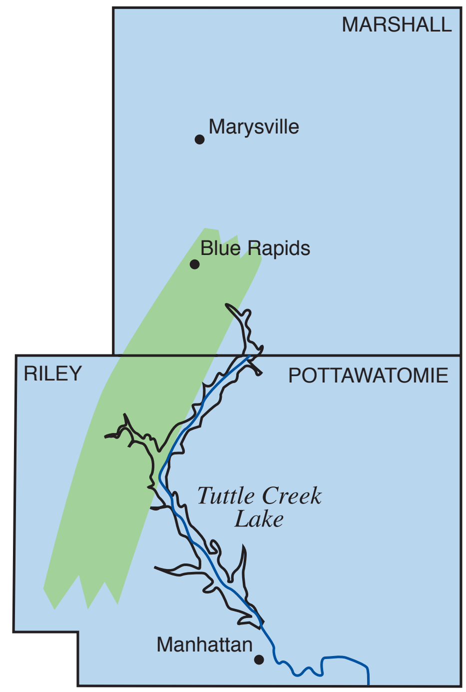

Figure 1. Location of kimberlites in northeastern Kansas.

History of Kimberlites

Diamonds were recovered in India as early as 300 B.C. and have been found on all continents since that time. In 1866, children in the Cape Province of South Africa found a white pebble on the banks of the Orange River that turned out to be a 21.25-carat diamond. By 1869, a full-fledged diamond rush was underway. By tracing diamonds upstream, prospectors noted that soils where diamonds occurred also contained garnets, ilmenites, and clinopyroxenes, minerals rarely found in soils. In 1870, a farmer spotted the same minerals on his own farm and, after only a week of searching, recovered a 50-carat diamond. This was the first site in the world where

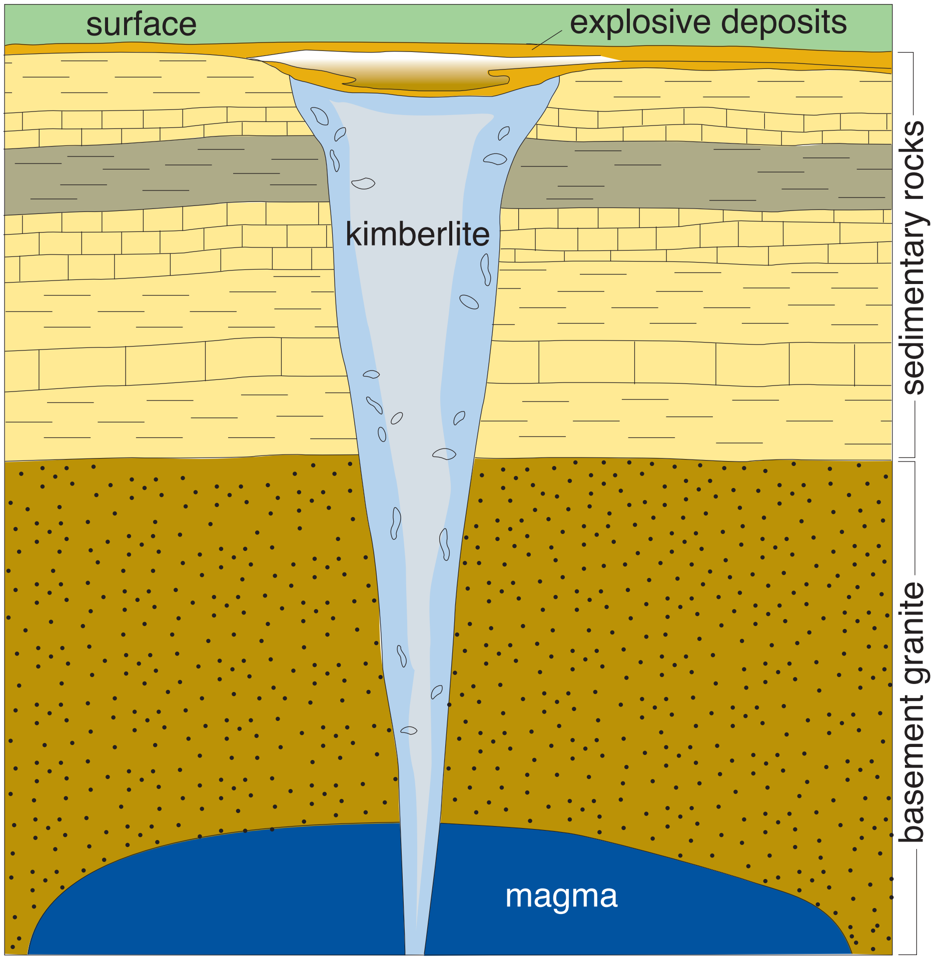

Figure 2. Generalized diagram of a kimberlite pipe.

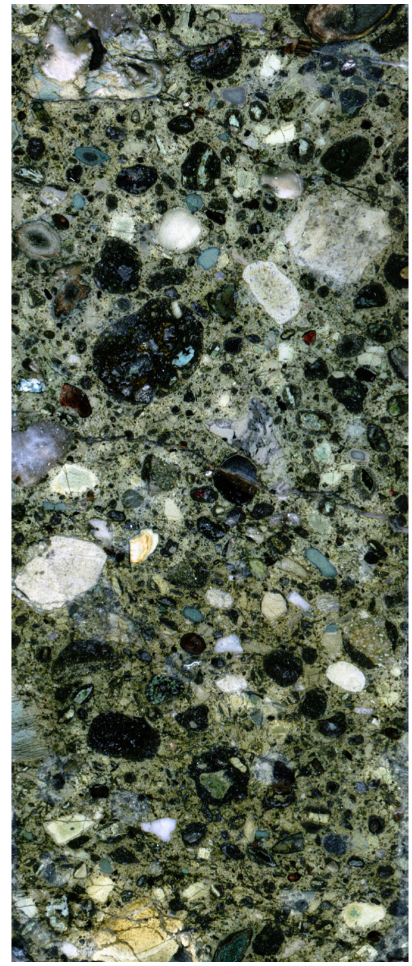

Figure 3. Polished kimberlite core sample.

diamonds were recovered from the clay-rich, soft, weathered kimberlite (known as yellow ground) that had carried the diamonds to the surface. With depth the weathered material turns into harder, bluish-gray rock called blue ground. Its characteristic color is used worldwide in prospecting for kimberlites.

Most of the world's kimberlites occur in South Africa, where over 3,000 kimberlite pipes have been found. Over 200 are known in North America, of which about 40 occur near the Colorado-Wyoming state line. Important new discoveries have been made in northern Canada in the last decade. Of the thousands of known kimberlites, fewer than about 1,000 contain diamonds, and of those, only about 50 to 60 have contained enough diamonds to be mined economically.

Kimberlites have been intruded into the earth's crust at various times. The intrusions are clustered in about 10 time periods ranging from 1,600 million years to about 55 million years ago. Kansas kimberlites were intruded in the Cretaceous Period, about 90 million years ago.

Kimberlites Occurrences in Kansas

Kansas kimberlites are located near Tuttle Creek Lake in Riley and Marshall counties (fig. 1). It is difficult to know what the countryside in the area looked like 90 million years ago, when the kimberlites exploded to the surface. However, by studying sedimentary rocks of approximately the same age deposited farther to the west, geologists conclude that the area was probably rather flat, very dry, and not too far from a seaway. In the 90 million years since the kimberlites were emplaced, much of the material has been eroded away. The kimberlites studied today represent deeper levels of the original kimberlite pipes.

The first kimberlites were discovered in Kansas in the late nineteenth century; at first, these kimberlites weren't recognized as igneous rocks (Brookins, 1970a). Several more kimberlites were identified in the 1930s and 1950s (Tolman and Landes, 1939; Byrne et al., 1956). Another kimberlite was discovered in 1969 by drilling at the Winkler crater site in northern Riley County (fig. 4). Previously, people had speculated that the crater was formed from a meteorite impact (Barringer, 1964; Freeberg, 1966).

Because kimberlites contain more magnetic minerals than the surrounding rocks, magnetic surveys are commonly used to find kimberlites that are not exposed at the surface. Aeromagnetic surveys were carried out in parts of Riley and Marshall counties in the early to middle 1980s to explore for new kimberlites. Other means of searching for kimberlites involve panning creeks and rivers to search for indicator minerals, such as garnet, that typically occur in kimberlites. Both methods were used in Kansas and, as a result, four more kimberlites were identified.

Recently, the Kansas Geological Survey used aeromagnetic survey data (donated by Cominco American, Inc.) to delineate other potential kimberlites. Detailed magnetic surveys (fig. 5) on the ground were then conducted at locations derived from the aerial surveys, and drilling in the fall of 1999 confirmed the presence of three additional kimberlites. These are the Tuttle, Baldwin Creek, and Antioch kimberlites. The Tuttle kimberlite is covered by only a few feet of soil, the Baldwin Creek by 25 feet (7.5 m), and the Antioch by 21 feet (6.4 m). Each of the three kimberlites was cored to a depth of 300 feet (91 m) for further studies.

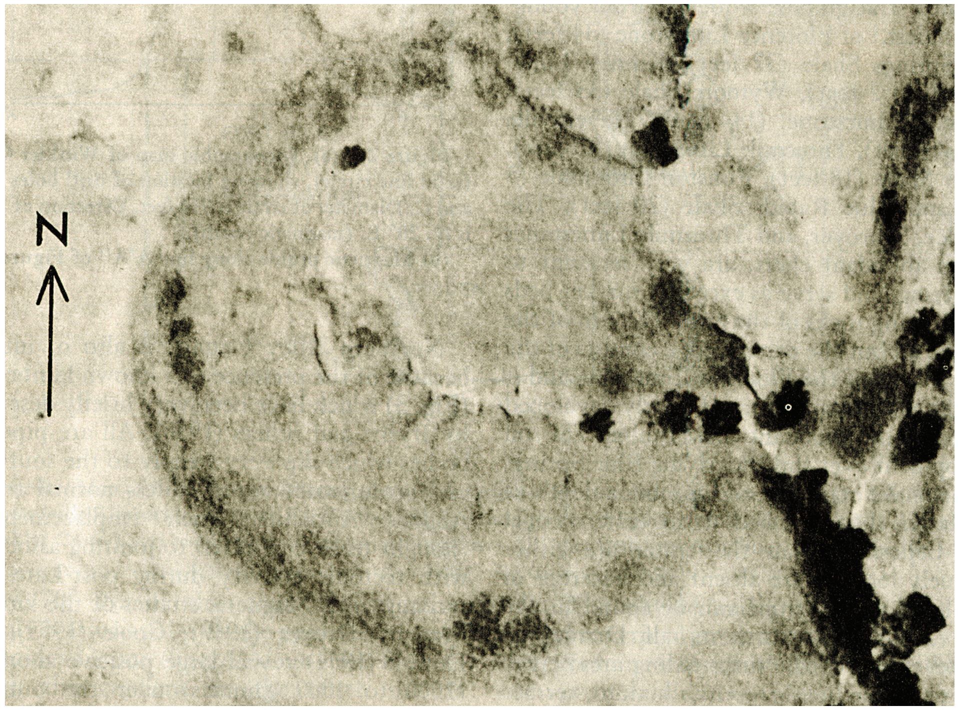

Figure 4. Aerial photo of the Winkler crater (Brookins, 1970, GSA Bulletin 81, fig.1).

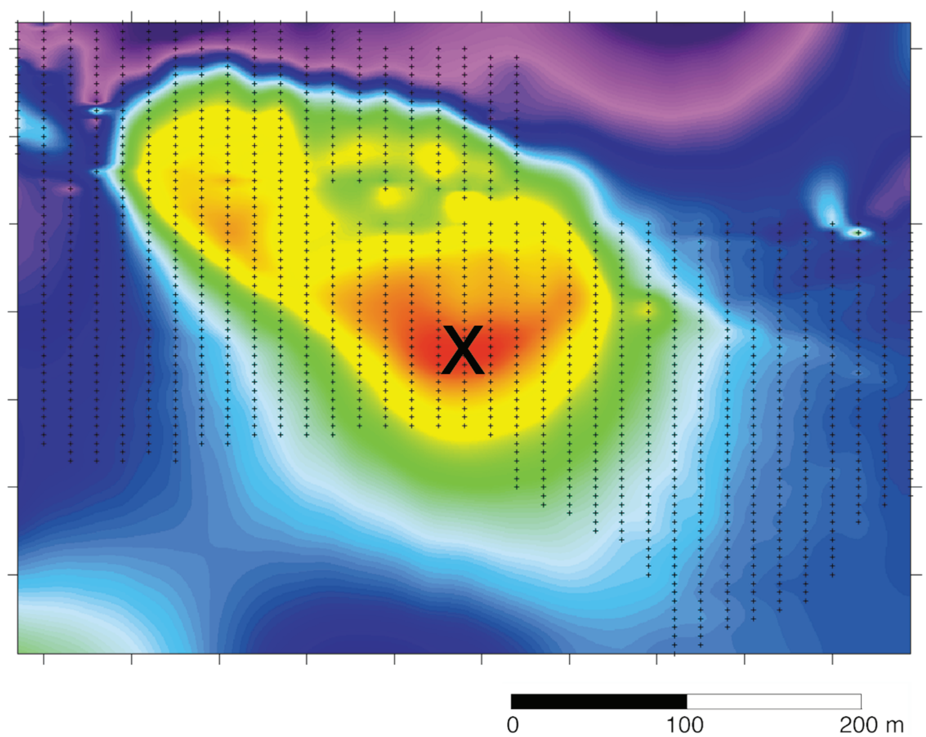

Figure 5. Image showing the results of magnetic surveys conducted at the Baldwin Creek kimberlite site in Riley County, Kansas. The red area in the center indicates the strongest magnetic readings. An "x" marks the drill site. The yellow area roughly outlines the boundaries of the kimberlite.

Economic Potential of Kimberlites

Diamonds are the only mineral of economic value potentially present in kimberlites. Diamonds are the hardest substance known and their brilliance makes them a popular gemstone. They are composed of pure carbon, one of the most common mineral-forming elements, and best known in the form of coal. Diamond is the stable form of carbon at high pressures and temperatures. If the chemistry, the pressure, and the temperature conditions are just right at the depths where kimberlite magma is generated, diamonds can crystallize. Diamonds can be preserved in kimberlite magma, which serves as a kind of high-speed elevator to the surface.

The two types of diamonds commonly recovered from kimberlites are gemstones and industrial diamonds. Industrial diamonds, commonly referred to as bort, are used in industrial tools and equipment, such as drill bits. Because the price of bort diamonds is so low, it is uneconomic to operate a mine that produces only bort. Most economical diamond mines produce somewhere between 20 and 40 percent gem-quality material.

Kimberlite mining causes relatively few environmental problems. Unlike many other ores, kimberlite does not contain potentially harmful sulfides, which can cause water and soil to become acidic. In addition, the process by which diamonds are recovered from the rock is relatively simple. The rock is crushed and the diamonds, being denser, are concentrated, together with some other heavy minerals, using centrifugal diamond pans and vibrating grease tables to which the diamonds stick.

There is no record that diamonds have been found in Kansas, either in kimberlite rock, stream gravels, or glacial deposits. Why some kimberlites contain diamonds and others don't is not well understood. Nonetheless, even without diamonds, kimberlites are scientifically important because they provide clues about the deep subsurface, snapshots of an otherwise inaccessible region deep within the earth.

Glossary

Aeromagnetic survey: A survey made with a magnetometer carried on an airplane. A magnetometer measures the earth's magnetic field and its changes. Rocks containing larger amounts of magnetic minerals register a higher response on the magnetometer.

Clinopyroxene: A group name for a number of pyroxene minerals that have similar crystal forms. They are silicates commonly containing aluminum, magnesium, calcium, and iron in their crystal structures.

Crust: The outermost layer or shell of the earth, representing less than 0.1% of the earth's total volume.

Garnets: A group of silicate minerals of which the dark red- to black-colored mineral pyrope is the typical garnet occurring in kimberlites. Pyrope is a silicate mineral containing magnesium and aluminum in its structure.

Igneous rock: A rock that solidified from molten or partly molten material.

Ilmenite: An opaque, black mineral containing iron and titanium.

Magma: Naturally occurring molten rock material, generated within the earth and capable of being intruded into other rocks or extruded onto the surface of the earth.

Mantle: The zone of the earth below the crust and above the core.

Olivine: An olive-green, silicate mineral rich in magnesium and iron. It is a common rock-forming mineral in the lower part of the crust and the upper mantle.

Peridotite: A general term for a coarse-grained igneous rock composed chiefly of the mineral olivine, with or without other magnesium-rich, dark-colored minerals.

Sedimentary rocks: A rock resulting from the consolidation of loose sediment that has accumulated in layers.

Ultrabasic: A rock containing virtually no quartz or feldspar and made up primarily of iron- and magnesium-rich minerals.

References

Barringer, R. W., 1964, World's meteorite craters, "Astroblemes": Meteoritics, v. 2, p. 169-174.

Brookins, D. G., 1970a, The kimberlites of Riley County, Kansas: Kansas Geological Survey, Bulletin 200, 32 p. [available online]

Brookins, D. G., 1970b, Kimberlite at Winkler Crater, Kansas: Geological Society of America, Bulletin 81, p. 241-246.

Byrne, F. E., Parish, K. L., and Crumpton, C. F., 1956, Igneous intrusions in Riley County, Kansas: American Association of Petroleum Geologists, Bulletin 40, no. 2, p. 377-380.

Freeberg, J. H., 1966, Terrestrial impact structures--A bibliography: U.S. Geological Survey, Bulletin 1220, 91 p.

Jackson, Julia A., ed., 1997, Glossary of Geology (4th ed.): Alexandria, Virginia, American Geological Institute, 769 p.

Tolman, C., and Landes, K. K., 1939, Igneous rocks of the Mississippi Valley lead-zinc districts, Chapter 3; in, Contributions to a Knowledge of the Lead and Zinc Deposits, E. S. Bastin, ed: Geological Society of America, Special Paper 24, p. 71-103.

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The Kansas Geological Survey (KGS) is a research and service division of the University of Kansas that investigates and provides information about the state's natural resources. KGS scientists pursue research related to surface and subsurface geology, energy resources, groundwater, and environmental hazards. They develop innovative tools and techniques, monitor earthquakes and groundwater levels, investigate water-quality concerns, and map the state's surface geology.

The KGS has no regulatory authority and does not take positions on natural resource issues. The main headquarters of the KGS is in Lawrence in the West District of the University of Kansas, and the Kansas Geologic Sample Repository of the KGS is in Wichita.

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