ART. IV.—*Kunzite and its Unique Properties;* by CHARLES BASKERVILLE and GEORGE F. KUNZ.

IN a recent investigation* made by us on the behavior of a large number of minerals and gems with various forms of radiant energy, including the emanations, as well as on the production of luminescence in some cases by other physical means, the new variety of spodumene, designated kunzite, was found to be peculiarly sensitive, and to exhibit some remarkable properties.

In general, as shown by these investigations, the gem-minerals were little affected by ultra-violet rays; but three species exhibited a high degree of responsiveness to these and to all forms of radio-activity, so far experimented with. These minerals were diamonds of certain kinds; willemite (zinc orthosilicate), which in some cases has been used as a gem-stone, and kunzite. The behavior of the last, as noted in various experiments, is unique and will be briefly described here by itself.

1. *Attrition and heat.*—Kunzite does not become luminous by attrition, or rubbing. Several specimens were held on a revolving buff cloth making 3000 revolutions per minute, so hot as to be almost unbearable to the hand, and still it failed to become luminous. Wollastonite, willemite and pectolite are, however, very tribo-luminescent.

As to luminescence induced by heat alone, it was found that kunzite does possess the property of thermo-luminescence to some extent, with an orange tint and at a low degree of heat.

2. *Electricity.* — The mineral assumes a static charge of electricity, like topaz, when rubbed with a woolen cloth. On exposing kunzite crystals of different sizes to the passage of an oscillating current obtained from large Helmholtz machines, the entire crystal glowed an orange-pink, temporarily losing the lilac color. A well-defined, brilliant line of light appeared through the center, apparently in the path of the current. On discontinuing the current, the crystal gave the appearance of a glowing coal. It was not hot, however, and the phosphorescence lasted for forty-five minutes.

Three large crystals, weighing 200, 300 and 400 grams each, were attached to copper wires so that the current passed in one instance from below up, and from the other upwards across the crystal—first across the prism, then parallel with the prism. In each instance the crystals became distinctively luminous, a pale orange-pink, and between the two wires a bright almost

* Science, N. S., xviii, 769, 1903.

transparent line passed from one wire to the other; in reality, as if the two elongated cones crossed each other, the line of the path being transparent at the sides, whereas the rest of the crystals appeared translucent. After the exposure of two minutes, they were laid upon photographic plates and in five minutes produced a fine auto-print, herewith shown. The crystals continued to glow for forty-five minutes.

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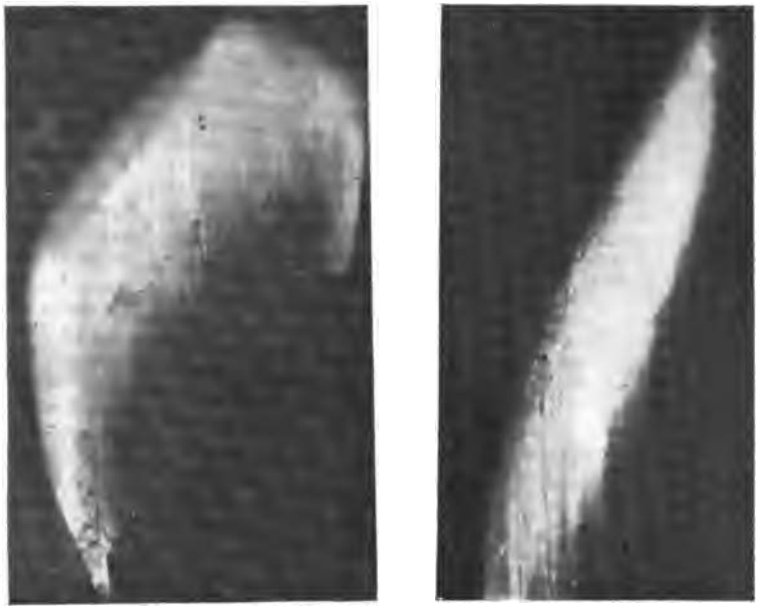

FIGURE 1.—Self-print made by the exposure of crystal of kunzite to the Roentgen rays for five minutes. Note the frond-like emanations at the ends of the crystal.—Reduced one-half.

FIGURE 2.—Auto-print of crystal of kunzite luminescence induced by an oscillating current obtained from a Helmholtz machine.—Reduced one-half.

When a cut gem is suspended between the two poles, it becomes an intense orange-pink color, glowing with wonderful brilliancy. The discharge seemed as if it would tear the gem asunder, although actually it was unaffected.

3. *Ultra-violet rays.*—These invisible rays, produced by sparking a high voltage current between iron terminals, caused kunzite, white, pink or lilac, to phosphoresce for some minutes. The white responded most readily.

4. *Roentgen, or X-rays.*—All forms of kunzite become

strongly phosphorescent under these rays. An exposure of half a minute caused three cut gems to glow first a golden-pink, and then white for ten minutes. The glow was visible through two thicknesses of white paper, which was held over it. A large crystal excited for five minutes afterward affected a sensitive photographic plate.* Another crystal, exposed for ten minutes, was laid for five minutes on a sensitive plate.† The resulting auto-photograph was clear and distinct, but presented a very curious aspect not seen by the eye—as of a misty or feathery outflow from the side and termination of the crystal, suggesting an actual picture of the invisible lines of force. The other varieties of spodumene, mineral material and cut gems, failed to show this property. We are not yet in a position to offer a satisfactory explanation of the above.

Whereas kunzite is so responsive and fluorescent and so beautiful upon exposure to the X-rays, it is, however, like all silicates, opaque to the ray itself. Four crystals weighing 100, 200 and 400 grams each, were exposed to the Roentgen ray for two minutes. They became first a beautiful rose-orange, then assumed a white phosphorescence, and at the end of forty-five minutes there was still a faint residual glow. Two minutes exposure to the X-ray caused them to print a perfect auto-type (herewith shown, fig. 2). The glow in all instances showed first a rose-orange color, then a pale pink, finally resolving into a white fluorescence; the auto-print shows the feathery outlines of light or energy thrown out by the crystal.

5. *Conduct with radium preparations.*—Exposed for a few minutes to radium bromide with a radio-active strength of 300,000 (uranium being taken as unity), the mineral becomes wonderfully phosphorescent, the glow continuing persistently after the removal of the source of excitation. The bromide was confined in glass. Six hundred grams of kunzite crystals were thus excited with 127 milligrams of the radium bromide in five minutes. The effect is not produced instantaneously but is cumulative, and after a few moments exposure the mineral begins to glow, and its phosphorescence is pronounced after the removal of the radio-active body. The luminosity continued in the dark for some little time after the radium was taken away. No other varieties of spodumene examined, including hiddenite, gave like results. In this respect, as with the Roentgen rays, the kunzite variety stands by itself.

When pulverized kunzite is mixed with radium-barium chloride of 240 activity or carbonate of lower activity, the mixed powder becomes luminous and apparently remains so permanently; i. e., in several months no loss has been observed.

* Science, N. S., xviii, 303, 1903.

† This was made by Dr. H. G. Piffard of New York City.

The same is the case if pulverized wollastonite or pectolite be used instead of the kunzite. When either of these mixtures is put in a Bologna flask and laid on a heated metal plate (less than red-hot), the powder becomes incandescent and remains so for a long time after removal.

These three minerals phosphoresce by heat alone, as was mentioned above in regard to kunzite. Perhaps this luminosity of the mixed powders at the ordinary temperature may be accounted for in part by the evolution of heat* on the part of the radium compounds, but there are experimental reasons which cause us to reject such explanation for the total effect.

The *emanation* of radium, the α-rays, according to Rutherford† are condensed at a temperature of $-130°$ to $-140°$ C. The emanations were driven from radium chloride by heat and condensed with liquid air on a number of kunzite crystals, according to a method which will be described by one of us (B) and Lockhart in another paper, and *no phosphorescence observed.* Consequently *kunzite responds only to the γ-rays*, which are believed to be virtually Roentgen rays.

6. *Actinium.*—A sample of the still more rare and novel substance discoverd by Professor Debierne‡ and received from him through the courtesy of Professor Curie, was also tried as to its action upon kunzite and some other minerals. The actinium oxide, with an activity of 10,000 according to the uranium standard, gave off profuse emanations and affected diamonds, kunzite and willemite in a manner similar to the radium salts, with quite as much after-continuance. However, we have not tried the condensation of these emanations upon the minerals by refrigeration.

The peculiar properties of the kunzite variety of spodumene, which have been enumerated, have not been observed in any other of the gem or gem-minerals that we have examined. It is barely possible that the small amount of manganese may have much to do with it, but from our present knowledge basing a chemical explanation thereon is idle.

* P. Curie and Laborde, Comptes Rend., cxxxvi, 673.
† Phil. Mag., v, 561. ‡ Compt. Rend., cxxix, 593.