Rubies and Sapphires

Contributed by Administrator
Tuesday, 13 November 2007
Last Updated Tuesday, 13 November 2007

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The ruby and sapphire share with the diamond, the emerald, and the pearl the position of the most precious jewels in the world. However, the arbitrary distinction between precious and semiprecious stones should be approached with caution since the desirability of any particular gem will depend largely on the prevailing fashions. What may be precious and much sought after in one period of history may have to give way to some rival at a later date. The leading position of these five gems has so far remained unassailed, and, while there may be times when one of them becomes more fashionable than the others, their beauty and rarity have assured them a permanent place among the first five.

Chemically, rubies and sapphires are composed of the simple compound, aluminum oxide, known as corundum, which has the formula A1203. Corundum occurs in nature in a startling variety of colors, and both rubies and sapphires are chemically the same substance; their names merely indicate their different colors.

On the hardness scale, corundum immediately follows diamond, and is thus the second hardest mineral in the world. In its natural form, corundum is found in well-shaped crystals that belong to the trigonal crystal system. Broadly speaking, gem corundum can be divided into two groups: (1) all material that is truly red in color and that is called rubies, and (2) all the many other shades known as sapphires.

Pure corundum is rarely found in nature in a clear form. Moreover, because of its lack of color and sparkle, pure corundum is rarely cut as a gem, and most so-called white sapphires used in cheap jewelry are of syn¬thetic origin. Yet, if small traces of a chemical substance known as chromic oxide, Cr203, intrude into the crystal structure of the hitherto colorless corundum, it turns red and is transformed into a ruby. Its beauty, however, does not depend on the red color alone, but involves one more of the mysteries of light, known as fluorescence. This phenomenon can be illus¬trated by shining a beam of blue light on a ruby in an otherwise darkened room and then viewing it through a red filter.

Normally, if one looks through a red filter at an object illuminated only with blue light, practically nothing will be visible because the red filter will have absorbed all the blue light rays and none of them will be able to reach the eyes. But the ruby is an exception, and it suddenly glows in the dark like a piece of red-hot coal. The explanation is that the ruby has the ability to absorb the shorter blue and violet wave lengths of light and re-emit them as red light of a longer wave length. The fine fluorescent glow can also be stimulated by the ultra¬violet rays present in sunlight, which incidentally are the same rays that can cause sunburn.
The ruby is not the only gem stone that has these fluorescent qualities.

Many others of quite different composition show a similar phenomenon, but it must be remembered that fluorescence is not an essential property of any of the gems, and it may vary considerably from stone to stone. Many diamonds, for instance, display a sky-blue fluorescence when subjected to ultraviolet radiation, and this may vary from faint to brilliant. These gems are, in fact, so inconsistent in their response that it has been suggested this strange property might be used as a means of identifying pieces of diamond jewelry by photographing them under ultraviolet rays—a kind of finger¬printing process.

The best color in ruby is a deep, rich red, and the finest stones originate in Burma. They are found in crystalline limestone deposits that have been broken down by the influence of weather into a brownish clay from which the ruby crystals are mined. There are other sources—notably Ceylon—where rubies are found in what are called gem gravels. These consist of a multi¬tude of different rock materials that have been collected over a period of thousands of years by rivers and mountain streams and are washed into the valleys to be deposited in layers and terraces. Ceylon gem gravels are particularly rich in gem minerals and form one of the richest sources in the world.

Picking gem stones from tons of gravel may seem rather a tedious job, yet it is by far the most productive method, and a little consideration will show why. Mining direct from rocks entails the cumbersome operation of crushing the stones and concentrating them artificially before they will yield up their gems—rather like diamond mining from dry diggings. In the case of gem gravels, however, this breaking-up process has already been done by rain, wind, and frost. Further, some of the lighter rock materials will have been washed away by the action of rivers and streams, leaving the heavier materials to sink to the bottom. Since many gem materials fall into the heavier category, these gravels will contain a high proportion of a variety of gem stones.

As with the ruby, the color of sapphires is due to small quantities of chemical impurities. These may take the form of titanium oxide and a trace of iron oxide. Few people realize that sapphires can have many dif¬ferent hues and the general belief that sapphires can only be blue is quite incorrect. There are green, yellow, purple, and pink stones, with many intermediate shades. All of them owe their hues to small quantities of chemical impurities that were present in the aluminum oxide when it formed into crystals many millions of years ago. But, as with most other gem stones, the crucial factor that ultimately determines their value is not their chemical composition—important as this is when identifying them— but their appearance.

The most valuable sapphires are those of a fine blue color, and the best of them are found in Thailand. In Burma, they are found in association with ruby, and some of them can be of fine quality, while others may be so deeply colored that they appear almost black. Other localities where sapphires are found include India, Australia, the United States, and Ceylon. Ceylon gem gravels are particularly rich in sapphires, and many of the green, yellow, and fancy-colored stones come from there.
There is yet one more gem variety about which so far nothing has been said.

This variety is known as the star stones, which description reveals much of their peculiar properties. If a piece of star corundum is correctly cut and polished, with a rounded dome-shaped cabochon top, it will reveal a clearly marked six-rayed star on its curved surface. Usually, the color of these star rubies and sapphires is not as attractive as that of the more com¬mon stones, and they are not transparent, but this is compensated for by the attractive star that sparkles on their surfaces.
The secret of this play of light lies within the rough corundum crystals.

Try to imagine that such crystals contain three sets of parallel, silklike bundles of fine fibers that extend throughout the stone and intersect one another at angles of 60°. They may consist of fine needles of another min¬eral known as rutile, or they may be formed from ultrafine hollow tubes, or even from tiny particles which could not be seen under the microscope. These bundles of fibers are arranged in such a manner that they lie parallel to the lateral axes of the stone and at right angles to the vertical axis (see Fig. 38). The stone must be cut in such a manner that its long verical axis passes through the center of the dome-shaped top, thus making the silk fibers lie parallel to the flat girdle plane of the stone.

The first successful attempt to produce rubies and sapphires syrlthetically was made in the early part of this century by a Frenchman whose name was Auguste Verneuil (1856-1913). He invented a special apparatus gen¬erally known today as the Verneuil Chalumeau (see Fig. 39). He used as his raw material pure alumina powder (aluminum oxide) to which was added 2lA per cent chromic oxide to produce the red color of the ruby. The mix¬ture was placed into the apparatus, consisting essentially of two tubes. The upper tube, X, is wider above and constricted below and passes down the center of the lower tube, Y. It terminates just above the opening of Y in a fine nozzle. Oxygen is admitted through tube A. Vessel C carries the alumina powder and has at its base a cylindrical sieve of fine mesh. B is a small hammer that is operated at regular intervals, and a succession of rapid taps causes the alumina powder to fall down the tube. The amount is regulated by the varying height from which the hammer falls. Hydro¬gen is admitted through tube D into outer tube Y. The oxygen and hydro¬gen gases mix and are ignited at the outlet of tube X. As the powder reaches the outlet of tube X, it is melted by the intensely hot flame and falls upon the pedestal F, where the boule begins to grow. When the rounded crystal column, the boule (see Fig. 40) has reached the required size, the gases are cut off. E is a fire-clay screen surrounding the flame, with an opening in the front for viewing the boule during growth. As the boule grows, it can be lowered slowly by a screw arrangement at G.

While Verneuil was operating the device, a peculiar thing happened. As the molten mass began to cool on the fire-clay pedestal it did not return to its original powder form, but began to grow as a crystal, each cooling drop crystallizing in the proper alignment as it solidified. In outward appearance it bore little resemblance to a crystal because it was shaped like a rounded column with a narrow base, but, apart from its shape, it possessed all the properties of a natural ruby.
Verneuil's production methods have hardly been changed to the present day. Synthetic sapphires are manufactured by a similar process, and, by adding different chemical compounds to the alumina powder, a large variety of colors can be produced.

Fortunately, it is possible to distinguish natural rubies and sapphires from their synthetic cousins; the methods used are discussed in Chapter VII. Most of the commercial production of synthetic corundum is directed toward industry where its great hardness serves many uses. The bearings of better quality watches and those of many precision instruments are made from synthetic corundum. When reference is made to a 13-jewel watch, this actually means that the device contains 13 bearings made from synthetic corundum. Pick-up heads of modern phonographs are frequently fitted either with diamond or synthetic-corundum needles because of their extreme hardness and durability. When found in its impure form, naturally mixed with magnetite, corundum is known as emery and serves as an im¬portant polishing agent for all types of metal and stone work.

A more recent and exciting scientific and industrial use for synthetic corundum is in connection with the production of laser beams. In 1960, a group of scientists working for the Hughes Aircraft Corporation in Cali¬fornia discovered that an input of light energy into a synthetic ruby rod energized the chromium atoms that give the ruby its characteristic red color, causing them to emit pure red light of a fixed wave length, which emerges in the form of a nearly parallel beam from the end of the rod. It was pointed out earlier that natural or synthetic rubies will emit red fight if suitably stimulated, but what makes the laser beam so special is that the chromium atoms inside the ruby rod emit red fight in unison instead of at random. The name "laser" is an acronym of the somewhat cumbersome phrase /ight amplification by stimulated emission of radiation. This gives a clue to the origin of the powerful laser beam.

The technical principle is relatively simple. Mirrors are placed at either end of the ruby rod, and, as soon as the flash from a discharge lamp ener¬gizes some of the chromium atoms within the rod, the light they emit is reflected backward and forward by the mirrors, building up in intensity as it stimulates other chromium atoms to emit in step; that is, the atoms emit light so that the peaks of the wave length come at the same instant. The result is a tremendous, but very short, burst of energy lasting only a fraction of a second. If suitably focused with an ordinary lens, a laser pulse can blast a hole through a Vs-inch-thick sheet of steel. The heat created is tremendous, and the temperature in the minute area where the laser beam is focused rises almost instantaneously to many thousands of degrees centigrade. This concentrated source of energy has been applied successfully to a variety of scientific and industrial processes, ranging from surgery to communications. In the latter field, a laser beam replacing conventional cables can carry thousands of telephone conversations inside a pipe line, and, in this connection, experiments are currently being conducted by the Bell Telephone Company. Machines have also been devised to allow lasers to be used during delicate operations of the eye, and eye surgeons have successfully welded detached retinas back into place by means of a laser beam.

Promising experiments are also being conducted to apply the power of the laser to drill hard substances. Holes can be punched into diamonds, and the beam can be used to drill synthetic corundum used in bearings.
Most of the technological and medical applications of the laser beam are as yet in an experimental stage, but there is little doubt that in time this remarkable source of energy will play an increasingly important part in future industrial and scientific development.