The Story of Fluorescence

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THE STORY OF FLUORESCENCE

An explanation of ultraviolet fluorescence and a descriptive list of fluorescent minerals

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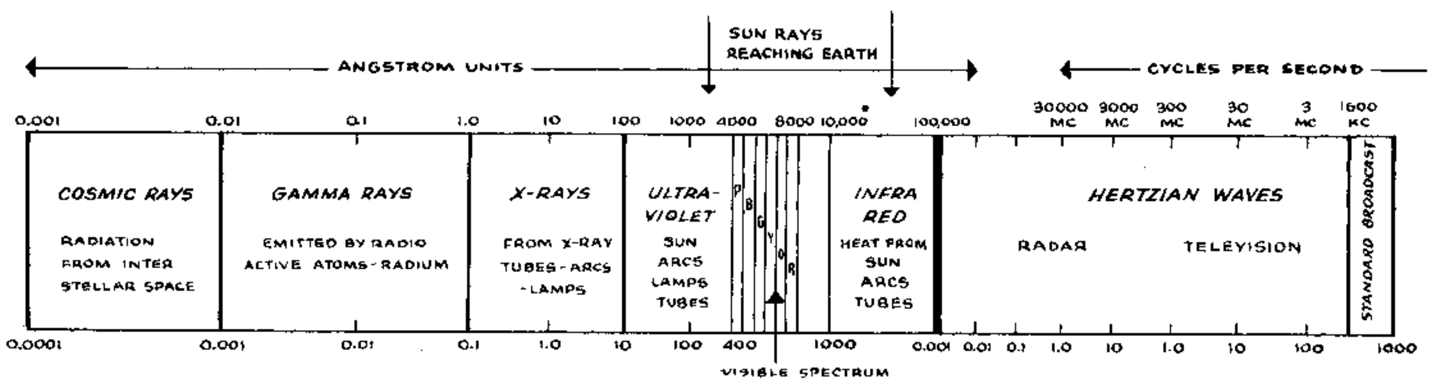
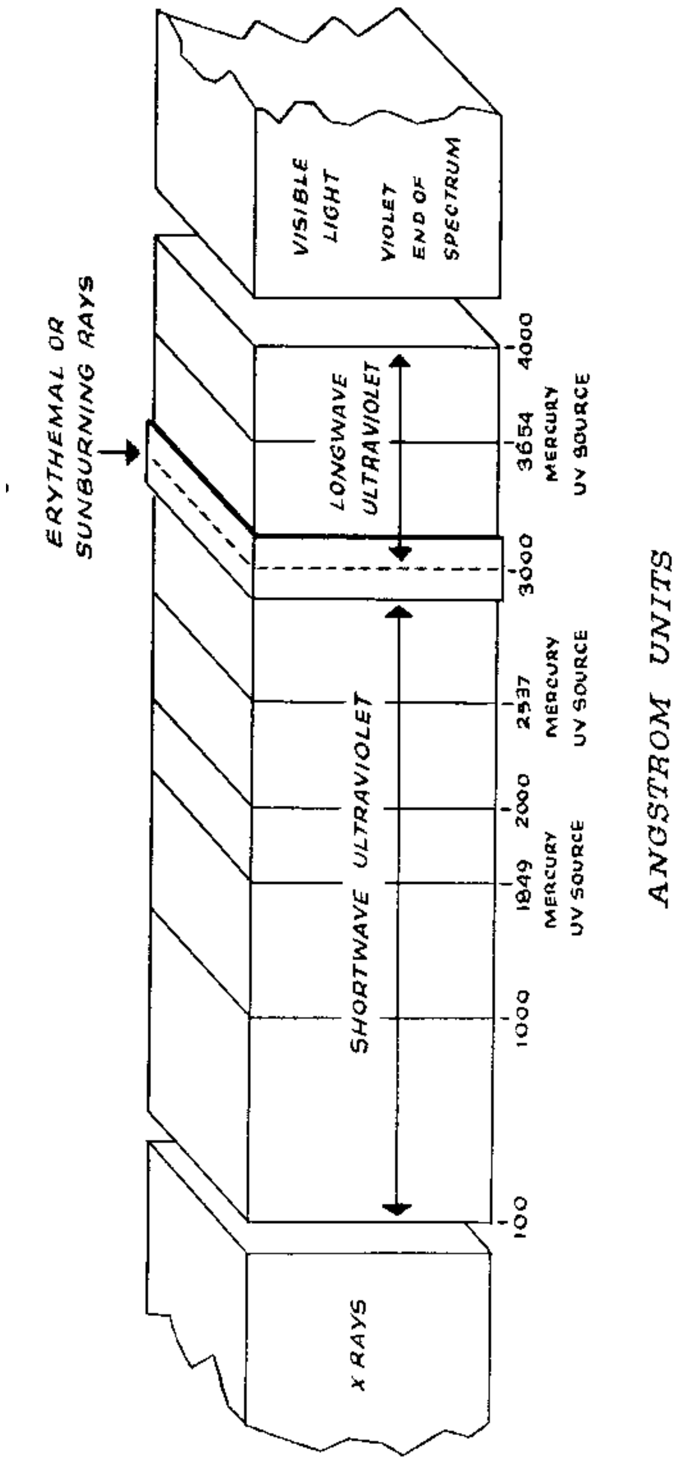


ELECTROMAGNETIC SPECTRUM


ERYTHEMAL OR
SUNBURNING RAYS
VISIBLE
LIGHT
VIOLET
END OF
SPECTRUM
LONGWAVE
ULTRAVIOLET
SHORTWAVE ULTRAVIOLET
X RAYS
4000
3654
MERCURY
UV SOURCE
3000
2537
MERCURY
UV SOURCE
2000
1849
MERCURY
UV SOURCE
1000
100
ANGSTROM UNITS

CAUTION

Be careful to limit exposure of your eyes to shortwave ultraviolet rays. These rays can "sunburn" your eyes and cause uncomfortable irritation. You should not look into a shortwave lamp when it is turned on.

Children's eyes are especially sensitive and if experiments require their working near a shortwave lamp for extended periods, we recommend the wearing of protective glasses. Any ordinary glasses will absorb the shortwave rays, but if there is prolonged exposure from the side, it is possible for the eyes to be irritated from rays entering the eyes from behind the lenses. Shortwave rays are largely absorbed by most surfaces they strike, but they can be reflected by polished metals and plaster and similar surfaces.

If you follow these simple precautions you should have no problem. At Raytech we have worked for many years using tens of thousands of ultraviolet lamps and have experienced nothing more than a few slight cases of eye irritation. For your information, shortwave ultraviolet and longwave ultraviolet are defined on page 8 of this book. Longwave ultraviolet normally does not irritate the eyes, but we would not recommend staring into an ultraviolet lamp any more than we would recommend staring into any other light.

WAVELENGTH

THE ANGSTROM UNIT

The Angstrom unit is on-hundredth of one-millionth of one centimeter, or about four billionths of an inch. The Angstrom unit is usually abbreviated a.u., A.U., A, or Å. The scientific symbol for Angstrom unit is λ, the Greek letter lambda. Another unit used to measure the wavelengths of light is the millimicron, usually abbreviated μ, the Greek letter mu. The millimicron is equal to one-thousandth of one micron, or 10 Angstrom units.

COLOR

The wavelength of light determines its color. White light is a mixture of wavelengths covering the visible range from about 4000 A to 7000 A. The color of an object depends on which color or wavelengths of light it reflects and transmits. A red apple is red because when struck with white light it reflects primarily the red wavelengths of light (6000 to 7000 A) and absorbs most of the other wavelengths. A green glass is green because it reflects the green light that strikes it. If it is transparent, it also transmits a portion of the green light. The remaining wavelengths of light are absorbed and turn to heat.

SELECTIVE ABSORPTION

In the section titled color we found that it is the selective wavelength reflection or transmission and absorption that determine the color of an object. An object is yellow because it reflects (or transmits) yellow light wavelengths to the exclusion of all other visible light wavelengths. The concept of selective absorption is just as applicable outside the visible spectrum as it is with the wavelengths we can see. For example, the filter on the shortwave is transparent to the shortwave ultraviolet, yet opaque to visible light. On the other hand, the plastic shortwave eliminator, or ordinary glass, is quite transparent to visible light yet almost totally opaque to shortwave ultraviolet. There are a great many useful applications of the fact that given substances will transmit radiations of one wavelength yet will absorb radiations of other wavelengths. Special heat absorbing glass windows will absorb heat (infrared radiations) yet transmit visible light. The human body will transmit visible light to a rather limited extent. X-rays will readily penetrate flesh, yet bones and teeth are sufficiently opaque to x-rays to cast shadows on x-ray film. As we know, this makes possible their examination inside the living body.

Chemical compounds are accurately analyzed by determining their absorption and transmission of various wavelengths of ultraviolet and infrared radiation. The fact that specific groupings of atoms in molecules will absorb specific radiation wavelengths permits precise identification of many organic compounds. Often these compounds would be very difficult to analyze by any other method.

Examinations in the infrared and ultraviolet spectrums are made with instruments known as spectrophotometers, which allow us to determine the “color” (selective absorption) of materials outside the visible spectrum. The spectrophotometer scans the test specimen with the various wavelengths of the spectrum and determines how much of each wavelength is either transmitted or reflected and how much is absorbed.

ULTRAVIOLET AND BEYOND

The ultraviolet region ranges from the shortest violet wavelengths of light that people can see, at about 4000 A, down to approximately 100 A, the upper end of the x-ray spectrum. The x-ray region extends down from the ultraviolet to about 1 Angstrom. Beyond the x-rays are the gamma rays, which are emitted by radioactive particles. Further out, beyond the lower end of the gamma rays at about 1/100 A, lie the cosmic rays. These are the mysterious radiations that originate somewhere in space and that constantly bombard the earth. It is believed that this continual bombardment of all living things by cosmic rays is one of the chief causes of mutations or genetic changes in plants and animals.

LONGWAVE ULTRAVIOLET

Longwave ultraviolet includes those radiations which lie just below the visible spectrum, in the range of about 3000 to 4000 A. This ultraviolet is commonly known as “black light” and is widely used in industrial inspection, theatrical work, medicine, biology, and advertising. Some minerals will fluoresce with longwave ultraviolet, but most of them react better to shortwave ultraviolet radiation.

SHORTWAVE ULTRAVIOLET

Shortwave ultraviolet includes the radiations below about 3000 A. The most common shortwave ultraviolet sources (mercury arcs) emit much of their energy at the single wavelength of 2537 A. Some longwave ultraviolet and some visible light are also emitted. A small amount of ultraviolet is generated at 1849 A, but little of this energy will pass through the glass tubes used in most lamps. Any ultraviolet that is radiated at the 1849 A wavelength will be absorbed by the air before it travels many inches. As a result of the absorption of the 1849 A, oxygen molecules in the air rearrange to form ozone, a very active oxidizing and deodorizing agent.

Shortwave ultraviolet (2537 A) can kill bacteria where there is direct exposure and is useful for this germicidal effect in food packing plants, hospitals, air conditioning systems, public rest rooms, etc. Also a great percentage of the fluorescent minerals react to shortwave ultraviolet. The tungsten ore scheelite, for example, is found by prospecting at night with a shortwave ultraviolet light and a battery pack. It is the shortwave radiations that are irritating to the eyes. Also they can produce a strong sunburn effect on the skin (erythema) with prolonged exposure. While longwave ultraviolet will pass through most glasses, plastics and transparent substances, shortwave ultraviolet will not go through many things. It will not go through ordinary glass or through plastics – with the exception of some thin films. This means that shortwave ultraviolet does not come through the windows of your house, cannot penetrate eyeglasses to harm your eyes and, in fact, could not come through the bulb of your ultraviolet light if it was not made of a special, high silica glass.

THE ULTRAVIOLET FILTER

All lamps that emit ultraviolet light also emit visible light which tends to mask any fluorescence that is occurring. Therefore, it is necessary to place in front of the bulb a dark purple glass filter that will block as much of the visible light as possible but will, at the same time, transmit the ultraviolet.

Several types of dark blue or purple glass can be used as a filter on a longwave lamp. Sometimes the longwave bulb itself will be made from a dark blue glass that acts as a filter. However, a filter for a shortwave lamp must be made from a very special kind of glass since, as we have already seen, the shortwave radiations will not pass through ordinary glass.

A DEFINITION OF FLUORESCENCE

Most commonly, fluorescence refers to the property of emitting visible light during radiation by ultraviolet. The visible light given off can be of almost any color, depending on the substance which is fluorescing and, to a lesser extent, on the wavelength of the ultraviolet that causes the fluorescence.

The word “Fluorescence” comes from the name of the mineral fluorite, in which a visible blue glow or fluorescence, resulting from the ultraviolet in sunlight, was noted and described by Sir George Stokes in the early 1800s. Sir Stokes made a rather comprehensive study of the phenomenon, which he called “fluorescence”.

Fluorescence is caused not only by ultraviolet, but can also be caused by other radiations such as x-rays and visible light. For example, a number of minerals will glow or fluoresce when exposed to x-rays. Minerals have also been found which luminesce in the infrared region when irradiated with ultraviolet rays or more commonly with visible light. Some 75 different mineral species in the collection of the National Museum have been found to fluoresce in the infrared region.

Since its discovery by Stokes, fluorescence has developed great practical significance. One of its most widespread applications is in the ordinary fluorescent light. The tube of a fluorescent light consists basically of a generator of ultraviolet energy. The inside of the tube is coated with a fluorescent powder or phosphor, which the ultraviolet causes to fluoresce brilliantly, thereby producing visible light.

THE CAUSE OF FLUORESCENCE

All kinds of radiation, including ultraviolet, are forms of energy. When ultraviolet light is directed at most substances, the energy of the light is absorbed and turns into heat. However, some substances have an atomic structure that is affected by the particular kind of energy that is ultraviolet light. In these cases the energy from the ultraviolet light, when it strikes an electron, gives that electron extra energy which causes it to move to an orbit in a shell further away from the nucleus (a higher energy level). This is illustrated in the figure titled “Electron Displacement”. Remember that an electron needs an exact amount of energy to stay in its own orbit in a particular electron shell and that any change in that amount of energy will cause the electron to move either toward the nucleus or further away from the nucleus. When this energy from the ultraviolet light strikes the electron and causes it to move away from the nucleus, the original orbit becomes empty and the electron shell is left with a gap that must be filled to maintain the electrical balance. An electron in an orbit closer to the nucleus would not have sufficient energy to move out, so the only way for the gap to be filled is for an electron in an orbit further from the nucleus to be pulled down into the empty orbit, filling the gap left in the original shell by the loss of the first electron. A replacement electron, in moving down, gives off a definite amount of its energy and it is this energy that we see as visible light or fluorescence. The small packets of energy given up by the electrons as they drop to lower energy levels are known as quanta. The radiated quanta are often called protons. What actually happens during fluorescence is that this process of energy exchange takes place rapidly with many, many electrons – some absorbing energy, some giving it off, so that the visible light we see is for all practical purposes continuous and not interrupted.

PHOSPHORESCENCE

We have just discussed how visible fluorescent light is radiated by a fluorescent material while it is exposed to ultraviolet. Now let’s see what happens when the ultraviolet light is removed. With most fluorescent substances, the electrons settle back quickly into their balanced orbits and there is no further radiation of visible light. But in some materials, the electrons are slow in returning to their normal orbits. In this case, the atoms continue to give off light as long as the electrons are returning to their normal state. This continued emission of light after the ultraviolet has been removed is known as phosphorescence. Some materials will phosphoresce for only a few seconds while others will continue to give off light (in ever diminishing intensity) for long periods. By using sensitive photographic plates, phosphorescent light has been detected as much as several years after the exposure to ultraviolet.

ACTIVATORS

As you know, not all substances are fluorescent – in fact, most of them are not. In substances that do fluoresce, it has been found in most cases that a small amount of some impurity must be present in order for fluorescence to occur. Few chemically pure minerals will fluoresce at all. But on the other hand, the amount of the impurity is critical and if there is too much, the fluorescence will either be diminished or completely eliminated. For example, the red fluorescent calcite from Franklin, New Jersey is activated by manganese in a quantity of about 3%. It has been found that manganese content in the calcite of more than about 5% or less than about 1% will not permit fluorescence. The amount and type of impurity present determine the color and intensity of the fluorescence. The mineral calcite seems to be particularly sensitive to impurity activation and specimens of calcite have been found that fluoresce in practically every color. The amount of activator can be as important as the type.

In recent years, the constant quest for ever improved fluorescent coatings (“phosphors”) for fluorescent lamp tubes and television screens has resulted in a great deal of study of the effects of fluorescence of both chemical activators and crystal structure variations.

COLLECTING FLUORESCENT MINERALS

Most minerals do not fluoresce; however, fluorescent minerals are apt to be found at almost any place.

If a battery adapter is available for your ultraviolet lamp, a field trip at night is the best way to locate fluorescent minerals. Where no battery pack is available, fluorescent minerals can be found by bringing rock samples to the light. This is particularly good as a group project. Gather together as many different rock samples as possible. The more varied the samples, the more likely that fluorescent minerals will be found. Sand and gravel samples are particularly good because they usually contain material from many sources. Mine, quarry and road cut samples are also good. Watch particularly for vein and crystal pockets which will be more likely to contain fluorescent minerals. There is always a chance of locating a mineral deposit of commercial or scientific value. In the back of this booklet is a list of most of the better known fluorescent minerals.

Where there is an interest in mineral collecting, it is worth investing in a good reference book or two. While much can be done by the independent collector, a mineral club is often the best source of specimens and information on where fluorescent minerals may be found. Gem and mineral shops frequently have a fluorescent display. Also there are exhibits of fluorescent gems and minerals in museums and private homes across the country.

Many collectors prefer to make a specialized fluorescent mineral collection; some of the possibilities include fluorescent crystals, fluorescent calcites in various colors, and fluorescent gemstones including such minerals as scheelite, spinel, willemite, ruby, benitoite, etc. Most collectors try to acquire large, showy pieces, but there is a great deal to be said for a collection of smaller, well-chosen, carefully displayed specimens. There is as much beauty and much less bulk and weight. Also, many fluorescent minerals are not available in large specimens and by concentrating on the smaller specimens, a more comprehensive collection can be built.

PRACTICAL APPLICATIONS OF ULTRAVIOLET

TAGGED POSTAGE STAMPS

Some years ago, the US and a number of other countries introduced fluorescent "tagged" stamps for automatic sorting in postal equipment. This has created a great interest among stamp collectors in the use of ultraviolet in stamp identification. Actually ultraviolet has been used by knowledgeable professionals for many, many years for the examination of fluorescent stamps and for the detection of alterations, repairs, forgeries, ink variations and erasures.

In an effort to reduce the rising costs of hand-sorting mail, a number of years ago equipment was developed that can automatically differentiate between classes of mail by the fluorescent glow or more particularly the phosphorescent afterglow of specially coated stamps under ultraviolet radiation. A fluorescent substance such as that used on tagged stamps is known as a phosphor. The US tagged stamps all fluoresce and phosphoresce under 2537 A (shortwave) ultraviolet. They do not react to longwave (3660 A) radiations.

A number of US stamps have been issued in both tagged and untagged versions which can in no way be differentiated except under shortwave ultraviolet. Interesting examples of the stamp variations visible under ultraviolet are found in the Lincoln 4¢ stamp. An examination of a few random samples of the Lincoln 4¢ has revealed the following: Under visible light, all stamps appeared the same standard purple color. Under longwave ultraviolet, one appeared dull purple, the second a bright blue grey with bright blue-white borders (fluorescent paper) and the third a dull red-purple. Under shortwave ultraviolet, the first was red-purple, the second blue grey, and the third – the tagged stamp – was brilliant green.

Other older US stamps that have been tagged with a green fluorescent and briefly phosphorescent phosphor include the Washington

5¢ and the City Mail 5¢ commemorative. The 8¢ tagged airmail shows a bright red fluorescence and phosphorescence. Tagged, blue colored, airmail stickers show a brilliant red fluorescence and similar brilliant but short-lived phosphorescence. These stamps were first issued in Dayton, Ohio, the location of the first automatic sorting equipment.

For a number of years some issues of Canadian and British stamps have been tagged with fluorescent and phosphorescent bars that are not as readily detected as the US phosphors and for which a powerful lamp is a considerable advantage. Germany has issued many green fluorescent stamps and Switzerland, the Netherlands and Denmark have also issued tagged stamps for many years.

FLUORESCENT POSTAGE STAMPS

While the tagged stamps are all fluorescent under shortwave ultraviolet, we speak here of the fluorescent stamps that have not been specifically tagged for sorting but that have been printed with fluorescent inks. While the advent of tagged stamps created new interest in fluorescent stamps, they were not new, having been issued through the years by many countries. They actually date back to the 1800s and perhaps earlier. The characteristic of these stamps is that they glow in bright colors under an ultraviolet source and usually will react under longwave or shortwave ultraviolet, whereas tagged stamps react exclusively to shortwave ultraviolet.

An example of a spectacular, brilliantly fluorescent stamp is the German Dove of Peace one mark stamp. This stamp is a drab olive green in ordinary light, but under longwave ultraviolet it glows a brilliant green, showing the Dove of Peace in attractive non-fluorescent contrast.
An interesting thing often observed when examining stamps under ultraviolet is the variations in fluorescence of the paper on which the stamps are printed. For the most part, very old papers show little if any fluorescence while modern papers vary from non-fluorescence to brilliant blue-white fluorescence that is best observed in longwave ultraviolet. It is common for the same issue of stamps to

appear printed both on fluorescent and non-fluorescent paper. As mentioned previously, the US 4¢ Lincoln stamp not only appears as a tagged stamp but also in untagged varieties both on non-fluorescent and fluorescent papers.

The variations in fluorescence commonly found in papers can be vividly illustrated by shining a longwave ultraviolet source on a random group of envelopes. Some will appear dull purple while others will fluoresce in various degrees ranging to a brilliant blue-white.

The reason so many modern papers are fluorescent is that during their manufacture they are brightened by the addition of what is known as “optical bleach”. These so called bleaches do not actually bleach the paper but cause a blue fluorescence which is activated by the ultraviolet present in sunlight and in most artificial light sources. Fluorescent optical bleaches are almost universally found in household detergents used for the washing of clothes. Practically all white clothes now fluoresce and under a good source of longwave ultraviolet present a startling brilliance. It is these variations in fluorescence in papers, inks, etc, that make ultraviolet such a valuable tool in stamp examination.

POSTAGE STAMP FORGERIES AND ALTERATIONS

Since ultraviolet will reveal many differences in materials not seen in visible light, it can frequently be used to detect repairs, alterations and forgeries. Radley and Grant[1] report a number of interesting examples of such detection. One case mentioned is that of a very valuable Ceylon stamp on which the users frequently clipped the corners in an effort to make the stamp more attractive. Repairs have been made at times to restore these stamps. However in ultraviolet the replaced corners are readily detected by their difference in fluorescence from the original center. Other imitations recorded include a forgery of a ¼ sch. Holstein stamp of 1864 in which the

[1] J. A. Radley & Julius Grant, *Fluorescence Analysis in Ultraviolet Light* Chapman & Hall, Ltd., Publisher

ink fluoresced blue, while the original did not react at all to the ultraviolet. An imitation of a Baden number 1 issue obtained by dyeing a number 5 issue was readily detected under ultraviolet since it appeared much lighter in color that the genuine stamp.

A more recent counterfeit, readily detected under ultraviolet, is the Ryukyu Islands overprint Scotts #16. Under ultraviolet the genuine overprints show the ink as brown-black in appearance with a slight aura caused by diffusion into the paper of the oil from the printing ink. The counterfeit overprints have a blue-black appearance and do not show the aura.

Eradications, erasures and gum changes are all liable to leave fluorescent evidence which may be completely indiscernible in visible light. The possibilities are limited only by the ingenuity and curiosity of the user.

ADVERTISING AND THEATRICAL

In recent years there has been considerable growth in the use of fluorescent signs both indoors and outdoors. This growth has resulted from the continual search for unusual and spectacular advertising effects. Typically an ultraviolet light is shone on signs painted with fluorescent paints, preferably in a somewhat darkened area. The illustrations glow like live coals in many colors, resulting in an attention-getting display. The unique effects obtainable with fluorescent painting and ultraviolet light have also piqued the interests of many artists and fluorescent murals are now found in many homes.

One of the most widely known uses of fluorescence in art is in the theatre. Colorful staging is accomplished through the use of concealed ultraviolet lamps and brilliantly fluorescent costumes. For example, a strange floating effect can be achieved by one acrobat in black costume carrying another player in fluorescent clothing. A skull can be painted on a player's face with fluorescent paint – in fact ordinary Vaseline will do a good job. This skull would appear only when the visible lighting was replaced with ultraviolet.

The variety that can be obtained with fluorescent staging is limited only by the imagination of the producer.

CRIMINOLOGY

Ultraviolet has often been found extremely useful in criminology because many things that are invisible in ordinary light become plainly visible under ultraviolet. You may verify this by using an ultraviolet light to examine clothing, work areas and ordinary objects which are apparently perfectly clean. You will be amazed at the number of foreign substances that become apparent with this kind of an inspection. Indistinct fingerprints can be sharpened considerably by dusting with a fluorescent powder and examining with ultraviolet. Invisible stains from various body secretions such as urine, semen, pus, perspiration, etc, often fluoresce. Many garments, particularly white underclothing, will have an intense blue-white fluorescence because most of today's laundry detergents contain blue-white fluorescent dyes in order to make clothing look whiter and brighter, The use of ultraviolet lights underwater has been suggested as an aid in locating human bodies because of this common fluorescence of clothing.

CHEMISTRY

There are a number of specialized areas where ultraviolet is a powerful aid to the analytical chemist. For example, the familiar fused borax bead test can become extremely sensitive in identifying a number of rare earth metals. It is an especially good indicator for uranium. Exceedingly small amounts of mercury can be detected by the use of a shortwave ultraviolet source and a fluorescent willemite screen. Mercury vapor absorbs ultraviolet radiation and when present between an ultraviolet lamp and a fluorescent screen will throw a shadow on the screen. Quantitative measurements can be made on a number of the vitamins and various organic substances by measuring the intensity of the fluorescence in a standardized ultraviolet light.

MINING AND PROSPECTING

For many years ultraviolet has been a valuable tool in several phases of mining and prospecting. Many of the commercial ores fluoresce in a brilliant and distinctive manner. Most of these minerals react more strongly to the shortwave radiations.

The willemite zinc ore of the Franklin and Ogdensburg, New Jersey zinc mines fluoresces a bright green color while most of the encasing calcite rock glows a brilliant orange-red. In these mines ultraviolet has been used for hand-picking the ore from the waste rock. The ground-up tailings are also checked with ultraviolet to determine how effectively the ore has been separated from the waste.

A number of the secondary uranium minerals have a bright green fluorescence and it is often found that uranium ore is more easily traced with a portable ultraviolet light than with a Geiger counter. The zirconium ore, zircon, frequently has a golden brown fluorescence under shortwave ultraviolet. It is easily identified in sands by its distinctive fluorescence. Natural petroleum fluoresces blue-white under long-wave ultraviolet.

One of the most profitable uses of ultraviolet in prospecting has been for the location of the tungsten mineral scheelite which has a bright cream, white or blue fluorescence. Scheelite is usually very difficult to distinguish from the surrounding rock in ordinary light. The hue of the fluorescence of the scheelite is a measure of its molybdenum content.

A number of gems such as diamond and ruby often fluoresce brightly. The deep, rich red color of the finest rubies is partly a result of their fluorescing from the small amount of longwave ultraviolet present in sunlight and artificial light.

MEDICINE

In medicine, shortwave ultraviolet has been used for its powerful germicidal and erythemal effects in treating some skin disorders. Brief treatments with these rays have much the same effect as prolonged sunlight exposure, so care must be used to avoid excessive burning.

Longwave ultraviolet has found considerable use in medicine as a diagnostic aid. One of the most common and practical uses is in locating and identifying ringworm. The ringworm fungus fluoresces brightly under ultraviolet and can be detected whether it is on a human being or on physical equipment such as chair backs. The use of an ultraviolet lamp allows the school nurse to make a rapid survey of a large number of pupils for ringworm infection.

Both the white of the eye and the crystalline lens have natural white fluorescence, so the use of an ultraviolet light aids in detecting lens opacities such as beginning cataracts. Corneal foreign bodies, abrasions and lesions may be located and their extent determined more readily by dropping a little of the fluorescent dye fluorescein into the eye and then making an examination under ultraviolet light.

In lab work it has been found that the presence of porphyrin in the urine causes fluorescence. There have also been some studies made on the reaction under ultraviolet of certain substances present in the urine that are apparently determined by the store of nicotinic acid in the body.

While ultraviolet has for many years been a useful tool in the medical field for research, diagnosis and treatment, the future holds promise of even more important things to come. Work being done by US Government agencies with fluorescent staining and fluorescence microscopes holds hope for eventual rapid diagnosis within an hour where present culture growth methods require from three to seven days.

The Fluorescent Minerals

The most important fluorescent minerals are described on the following pages. They are arranged according to the color of fluorescence and alphabetically within each color group. The five color groupings are as follows:

Blue
Orange, Yellow, Gold
Green
Red, Pink
White, Cream

Because the fluorescent minerals of Franklin and Ogdensburg are so distinctive, they are described and listed alphabetically in the section titled "THE FLUORESCENT MINERALS OF FRANKLIN, NEW JERSEY".

The following abbreviations are used:

SW – shortwave
LW – longwave
ph – phosphorescence or phosphoresces
fl – fluorescence or fluoresces

BLUE

AMBER
Hydrocarbon
Hardness 2 – 2 ½
The fossil resin amber that is usually yellow, but also reddish, brownish or whitish in color, often fl blue-white; best LW.

BENITOITE
Silicate of barium and titanium
Hardness 6 – 6 ½
This unusual gem mineral is found in only one locality – near the

headwaters of the San Benito River in California. The blue crystals normally occur associated with neptunite in natrolite from which they are exposed by acid etching. Benitoite fl bright blue; SW.

CALCITE

Calcium carbonate

Hardness 3

Calcite, the most varied of the fl minerals, has been found fl in almost every color of the rainbow. The blue fl calcites are usually ph. They appear to be sulfide activated. While red fl calcite is fairly common in well crystallized form, blue fl calcite is usually found only in cleavable or granular masses.

The well known blue fl SW and ph calcite from the mercury mines at Terlingua, Texas will usually fl pink LW, especially in those specimens having a pink daylight color. Masses of cleavable blue fl and ph SW calcite have been found at San Saba, Texas and nearby Marble Falls. An interesting calcite from hear Hurley, New Mexico fl a dull pink LW. When first exposed to SW radiation the reaction is pink, but over a few seconds duration the color turns violet. The ph is blue. It is the combination of pink fl caused by electrons that rapidly return to their normal energy levels with the blue ph caused by the slow returning electrons that cause the apparently purple fl. The calcite from Terlingua also illustrates this phenomenon.

The blue fl and ph calcite similar to the San Saba material has been found in Indiana.

CELESTITE

Strontium sulfate

Hardness 3 – 3 ½

Many of the celestite crystals found in the sulfur mines of Sicily will fl a faint blue both LW and SW. These specimens are particularly showy when the fl celestite is implanted on an orange or pink LW fl calcite background. Both the celestite and the calcite usually have a brief greenish-white ph.

DIAMOND

Native carbon

Hardness 10

Gem diamonds have been found that fl in a variety of colors including green, orange, red and blue, usually best LW. Blue is the most common fl color. Diamonds react well to the longest ultraviolet rays and even to the shorter wavelengths of visible light. The blue-white color of a fine diamond is often enhanced by its daylight fluorescence.

FLUORITE

Calcium fluoride

Hardness 4

Historically fluorite is the best known fl mineral. In fact the word "fluorescence" is derived from the name of the mineral in which the phenomenon was first noted and described.

Blue is the most common fl color in fluorite. Intensity is usually best LW, diminished SW.

The outstanding localities for fl fluorite are the mines of Cumberland and Durham, England where outstanding groups of fl crystals have been found in quantity and variety. The natural color of these crystals is purple, green or yellow with the best fl usually noted in the purple crystals. A portion of the daylight color of these specimens results from their fl in the LW ultraviolet present in ordinary white light. Most of these crystals are cubic in form and often consist of parallel growths of smaller crystals. There are a number of localities in the United States where blue fl fluorite has been found. Clear green masses have been found in Arizona, New Mexico and elsewhere. Large, clear green octahedral crystals have been found at Westmoreland, New Hampshire. Blue cubic crystals come from New Mexico. In Madoc, Ontario transparent green cubo-octahedral crystals are found at many of the small fluorite mines that are worked from time to time. The fl of the Canadian material is not nearly as bright as that from England.

A bright green fluorite that fl a brilliant blue LW has been imported from South Africa on a trial basis for use as a steel making flux. Several tons of this attractive green material has found its way onto the specimen market.

HYDROZINCITE

Carbonate-hydroxide of zinc

Hardness 2 – 2 ½

Hydrozincite is a secondary zinc mineral common as thin fl coatings resulting from alteration of sphalerite, hemimorphite and smithsonite. It usually fl bright blue-white SW only. Hydrozincite is found associated with zincite and calcite on the old mine dumps at Franklin, New Jersey. It is found associated with red fl calcite at Road Forks, New Mexico and Hurricane, Utah. It has been found in considerable quantity as earthy masses at Goodsprings, Nevada. Sometimes pockets in the earthy masses would be lined with tiny needle-like crystals of fl hydrozincite.

Elsewhere in the United States, hydrozincite has been found at Friedensville, Pennsylvania; Linden, Wisconsin; Marion County Arkansas; Joplin, Missouri; Cherokee County Kansas; Magdalena district, New Mexico; and Tintic district, Utah.

Outstanding fl specimens of hydrozincite have come from Mapimi, Durango, Mexico where brilliantly blue-white fl needle crystals of hydrozincite are associated with plattnerite and hemimorphite as cavity linings in limonite. This hydrozincite is unusual in that it not only fl blue-white SW but also dull peach LW.

Further information on fl hydrozincite is given in the “Franklin” fluorescent section.

SCHEELITE

Calcium tungstate

Hardness 4 ½ - 5

This important ore of tungsten is heavy, usually white, cream or gray in color, and is normally very difficult to distinguish from other minerals in the rock. However, its marked SW fl and non-fl LW make it very easy to locate and identify with ultraviolet. In fact, ultraviolet prospecting is practically the only way that scheelite is located. During World War II when tungsten was in great demand and short supply, a great deal of successful ultraviolet prospecting took place in the western United States.

In some of the Canadian gold mines the rock was checked after each blast and any scheelite ore was set aside. Scheelite has been mined in many areas of California, Nevada, New Mexico and Idaho. The dumps from practically any of the tungsten mines will produce fl specimens. Large masses of scheelite are not common, and well formed crystals are highly prized.

In the East, scheelite has been mined in Trumbull, Connecticut and also in South Carolina, but the bulk of the commercial development has been in the western states.

ORANGE, YELLOW, GOLD

ANGLESITE
Lead sulfate
Hardness 3
Anglesit often occurs in well developed crystals that fl yellow. It is found in lead mines in many countries associated with cerussite and galena.

BARITE
Barium sulfate
Hardness 3 – 3 ½
Most barites that fl react with a white or cream color, usually best LW. Hot Springs, North Carolina, however, has produced an unusual barite that fl a bright golden orange. This material is gray colored in daylight and fl in thin veinlets of bright color. Occasionally bright fl bands have been found an inch or so in width.

CALCITE

Calcium carbonate

Hardness 3

Calcite that fl orange has been found in the quarries at Crestmore, California. A sulfide vein at Lowville, New York has produced a calcite that fl bright orange in association with a more common red fl calcite and blue fl fluorite. Drusy crystal coatings and stalagtitic masses that fl in beautiful shades of orange, cream and pink are found in the sulfur mines of Sicily. Pale yellow fl calcite is found in several localities including crystal specimens at Bound Brook, New Jersey and cleavable masses at Marble Falls, Texas.

Caliche, a carbonate coating often found on the surface of desert stones, will often show an orange fl SW.

CERUSSITE

Lead carbonate

Hardness 3 – 3 ½

Found in many lead deposits. Commonly fl yellow LW and also in x-rays.

CHONDRODITE and NORBERGITE

Basic flusilicates of magnesium

Hardness 6 – 6 ½

The two minerals norbergite and chondrodite are similar in composition, appearance and fl and are not easily distinguished from one another. They often occur together at the same localities and are sometimes inter-grown. The daylight color of these minerals ranges from white through hyacinth red with the most common color being tan or honey-yellow. The fl ranges from bright golden yellow or yellow-orange to buff SW and is usually brightest in the lighter colored specimens. Fl LW is slight.

Fl chondrodite is found as scattered grains and crystals in the limestone of northern New Jersey at Sparta, Ogdensburg and Franklin. A similar occurrence in limestone is at Newcomb, New York.

CURTISITE

Carbon-hydrogen compound, probably $C_{24}H_{18}$

Hardness less than 2

The hydrocarbon curtisite has been found in the hot springs area of Skaggs Springs, Sonoma, California. Hydrocarbon infusions in travertine from the Clear Lake area of California have produced specimens with fantastic patterns which fl white, cream and pale green in swirls, bands, spots and flame-like growths.

DIAMOND

Carbon

Hardness 10

Diamonds have been found which fl yellow and orange. See diamond in the Blue section.

HACKMANITE

Complex silicate of sodium and aluminum containing chlorine and sulfur

Hardness 5 ½ - 6

One of the most interesting of all fl minerals is hackmanite, which is found near Bancroft, Ontario. It has also been reported from West Greenland, Kishengahr state, Rajputana, India and the Kola Peninsula, Lapland. Hackmanite commonly fl bright apricot LW and shows a similar but less brilliant fl SW.

When a block of nepheline containing hackmanite is first broken open the hackmanite will be easily distinguished by its brilliant raspberry red color. The color disappears within a few minutes exposure to daylight or artificial light. It can, however, be returned to its brilliant color by a few minutes exposure to SW ultraviolet. It will retain the bright raspberry red color as long as it is kept in the dark. On exposure to light it will once again fade. This color reversal can be repeated indefinitely. The property of reversing color with changes in light radiation has been called “reversible photosensitivity”. More recently it has been called “tenebrescence”.

MANGANAPATITE

Calcium phosphate containing fluorine and manganese
Hardness 5

Blue-green to white in daylight, manganapatite fl buff-brown to bright golden yellow SW. It is common in the pegmatites of New England and North Carolina. Excellent specimens have been found in the Portland, Connecticut area often in association with green fl hyalite or autunite. It usually occurs in scattered grains in feldspar. The lighter colored material seems to fl more brilliantly in general.

PECTOLITE

Silicate of sodium and calcium with water of crystallization
Hardness 5

Pectolite usually occurs in fibrous masses. Specimens that fl bright yellow and cream have been found near the Golden Gate Bridge in California. Pectolite from some of the New Jersey trap rock quarries shows some fl and more often a gold ph when exposed to an unfiltered SW light.

PHLOGOPITE

Silicate of magnesium, potassium and aluminum
Hardness 2 ½ - 3

A magnesium mica, usually light brown in color, phlogopite will sometimes fl buff-yellow SW. Fl phlogopite has been found at Franklin, New Jersey and Newcomb, New York.

PHOSGENITE

Chlorocarbonate of lead
Hardness 2 – 3

Crystals of phosgenite that fl yellow have been found at Monteponi, Sardinia.

POWELLITE

Calcium molybdate

Hardness 3 ½ - 4

While its natural color varies from straw yellow and greenish yellow to gray, greenish blue and almost black, powellite is readily distinguished by its creamy or golden fl SW but no fl LW.

Powellite is a secondary mineral usually formed by the alteration of molybdenite. It has been found in the United States in the copper and tungsten mines of Adams, Beaver and Tooele counties in Utah; also associated with copper in the mines at Houghton County, Michigan; in Nevada at Tonopah and near Oak Springs, Nye County; at Barringer Hill, Llano County, Texas; in California at the tungsten mines of Inyo and Kern Counties; in Arizona in Pima and Mohave counties; and also in Sierra County, New Mexico.

SCAPOLITE (WERNERITE)

Complex silicate of calcium, sodium and aluminum

Hardness 5 – 6

One of the most spectacular LW fl minerals is the yellow fl wernerite from the Grenville, Quebec area. The old original locality for this material produced a fibrous looking brilliantly fl material. The scapolite offered to the collectors in more recent years is more compact and varies in color from white to translucent greenish-yellow. The fl is spectacular brilliant yellow. Fl wernerite has also been found at Manawaki, Quebec. While it is not often noticed, wernerite has a weak but long lived ph after exposure to either LW or SW.

SCHEELITE

Calcium Tungstate

Hardness 4 ½ - 5

This important ore of tungsten fl blue-white when pure, but when it contains sufficient molybdenum the fl is yellow. Smaller molybdenum content causes a white fl. It is not unusual to find specimens of scheelite in which the fl varies from blue to yellow – sometimes a grain only a fraction of an inch across will show separate areas of blue, white and yellow fl. There are many important sources of scheelite in California, Nevada, New Mexico and Idaho. Scheelite has also been mined in Connecticut and South Carolina. The description in the Blue section gives further information.

SODALITE

Silicate of sodium and aluminum containing chlorine

Hardness 5 – 6

Sodalite from Moultonboro, New Hampshire fl golden brown LW. Fl sodalite is also found in a pegmatite on the Appalachian Trail at Beemerville, New Jersey.

SPHALERITE

Zinc sulfide

Hardness 3½ - 4

Sphalerite from a number of localities shows strong orange or golden brown fl usually best in LW. IT often has a lasting ph of the same color. Sphalerite is often thermoluminescent and triboluminescent also.

Fl sphalerite from Tsumeb, Namibia, Africa was available for many years. Similar fl sphalerite has been found at Bonanza, Colorado and Bisbee, Arizona.

Fl Sphalerite has also been found in the zinc mines at Franklin and Ogdensburg, New Jersey. Bright yellow fl SW coatings of secondary sphalerite have been found at Broken Hills, New South Wales, Australia.

TERLINGUAITE

Oxychloride of mercury

Hardness 2½

A rare mercury mineral named for its locality, the mercury mines of Terlingua, Texas. Terlinguaite is often seen as bright yellow fl spots SW associated with the well known blue fl and ph calcite of Terlingua.

TREMOLITE

Calcium magnesium silicate

Hardness 4 – 5

Tremolite from the talc mines of Balmat and Talcville, New York is noted for its orange LW and SW fl. This material ranges in response from non-fl through various shades of orange, pink and red. Specimens with mixed fl colors are not unusual and are quite attractive. A similar material has been reported from Ontario. Most tremolite fl dull gray-green or cream. It usually occurs as masses of needle crystals grown together.

ZIRCON

Zirconium silicate

Hardness 7 – 7 ½

Zircon often fl golden yellow to brown SW. Frequently identified in sands by its yellow fl. Fl zircons are found in the gem gravels of Myanmar (formerly Burma) and Sri Lanka. In the United States they are found in several localities in North Carolina. Many stubby fl crystals were found in a cotton field near Statesville, North Carolina. Night prospecting with a portable ultraviolet light was the most effective way of locating these crystals. Zircon is the ore of the metal zirconium.

GREEN

ADAMITE

Basic arsenate of zinc

Hardness 3 ½

The secondary zinc mineral adamite commonly occurs as drusy crystal coatings colored yellow, pale green or blue-green. The best green fl is seen in the pale green material. Fl is normally best SW but sometimes also good LW. The outstanding locality for fl adamite is Mapimi, Durango, Mexico where it occurs as drusy crystals lining cavities in limonite.

ARAGONITE
Calcium carbonate
Hardness 3 ½ - 4
Aragonite will sometimes fl green as a result of uranium activation. It is not unusual for the tips only of coral-like aragonite growths to fl green SW. Fl LW is usually weaker or else absent.

Aragonite with green fl has been found at Organ, New Mexico, at Bird Cave near Tres Hermanos, New Mexico and at Santa Eulalia, Chihuahua, Mexico. Magnificent fl specimens consisting of aragonite crystallizations rendered fl by the inclusion of the rare uranium mineral Novacekite have been found at Placeres de Guadalupe, Chihuahua, Mexico.

AUTUNITE
Hydrated phosphate of calcium and uranium
Hardness 2 – 2 ½
The most common fl uranium mineral is autunite which occurs widely in the pegmatites of New England and Mitchell County, North Carolina. It is also found in Bedford, New York, near Keystone, South Dakota and at the White Signal district, Grant County, New Mexico.

Autunite is usually found as small, nearly square crystal platelets, pale yellow or green in color. Magnificent specimens of cockscomb crystal aggregates have been found at the Daybreak Mine, Spokane County, Washington. Other outstanding localities for autunite include Autun, France – for which the mineral is named, Cornwall, England, Katanga district (formerly in Zaire) of the Democratic Republics of the Congo in Africa, and Mt Painter, South Australia.

DIAMOND
Carbon
Hardness 10
Gem diamonds have been found that fl various shades of green. See diamond in the Blue section.

HYALITE

Hydrous silica

Hardness 5 ½ - 6 ½

The hyalite variety of opal often has sufficient uranium content to fl brilliant green SW and sometimes a lesser green LW. Hyalite occurs as a thin transparent coating or as a stalactic crust.

Seams of hyalite are very common, coating fractures in pegmatites and granites. They account for most of the common green fl seen in the pegmatites of New England and North Carolina and also in the nepheline deposits of Ontario. These thin often invisible coatings will usually react with a brilliant green fl SW.

Outstanding fl hualite crusts have been found in the feldspar and mica mines of Mitchell County, North Carolina. Beautiful crusts, often tinted blue or green, have at times reached thickness of over an inch. More commonly these coatings are an eighth of an inch or less in thickness.

Hyalite is also found as a smooth botryoidal coating in cavities in volcanic rocks.

OPAL

Hydrous silica

Hardness 5 ½ - 6 ½

Common opal from several areas of the Western United States will fl green because of slight uranium activation. The outstanding locality is the Virgin Valley, Humboldt County, Nevada where large masses of fl common opal have been found. Fl is usually best SW although some reaction to LW is common.

QUARTZ, including varieties

Agate and Chalcedony

Silicon dioxide

Hardness 7

Crystallized quartz is very seldom fl; however, the agate and chalcedony varieties will often fl green or yellow-green, being activated by a slight content of uranium compounds. The fl is usually best SW and rather slight LW. Agate and chalcedony that fl green are found in a number of localities in the western United States and Mexico. The well known moss agates of Sweetwater County, Wyoming will generally fl a deep green. Agate from near Medicine Bow, Wyoming shows excellent pale green fl, depending on the amount of dark manganese inclusions. Fl chalcedony roses are found in various areas of Arizona. The southern Black Hills have produced quantities of chalcedony that fl green in association with a calcite that fl pink. Thunder egg agate nodules have fl areas have been found in both Oregon and New Mexico. Beautiful banded agate with green fl has come from Mexico.

URANIUM SALTS

Bright green fl is characteristic of a considerable number of secondary uranium minerals. This fl is usually best SW and is generally yellow-green in hue. The uncommon mineral andersonite sometimes fl brilliant blue-green. Autunite is the most frequently seen of the fl uranium minerals and is described separately.

Schroekingerite or Dakeite, a hydrated fluo-carbonate-sulfate of sodium, calcium and uranium with a hardness of 2½, is found as small concretions in clay at Wamsutter, Wyoming – also as a coating on tunnel walls at the Hillside Mine, Yavapai County, Arizona.

Swartzite, a hydrated carbonate of calcium, magnesium and uranium, is another mineral found as a coating on the walls of the Hillside Mine. It occurs as tiny prismatic crystals that fl bright green.

Andersonite, a hydrated carbonate of sodium, calcium and uranium is another brightly fl uranium mineral found as an efflorescence on the walls of the Hillside Mine. Andersonite has been found as a crumbly fl coating near Grants, New Mexico. The Grants material fl blue-green LW and brilliant blue-green SW.

The uncommon hydrated basic uranium sulfate minerals uranopilite, metauranopilite and zippeite all fl bright yellow-green. Of these three minerals, zippeite alone is found in the United States where it occurs in asphaltic sandstone at Fruita, Utah and in Gilpin County, Colorado.

The uranium mineral Novacekite has been found associated with aragonite in the area of Placeres de Guadalupe, Chihuahua, Mexico. These aragonite crystallizations with novacekite inclusions are often magnificent fl specimens.

WILLEMITE
Zinc silicate
Hardness 5 ½
The most famous locality for fl willemite is the zinc mines of Franklin, New Jersey where willemite is an important ore. Further description of willemite will be in the "Franklin" section. An excellent fl and ph willemite has also been found in Pinal County, Arizona in association with red fl calcite. Fl willemite has also been found in small quantities in some of the other Arizona mines.

RED, PINK

ARAGONITE
Calcium carbonate
Hardness 3
While aragonite usually fl orange or cream, pink fl aragonite has been found in the sulfur mines of Sicily and brilliant red fl crystals have been found at Broken Hill, New South Wales, Australia.

CALCITE
Calcium carbonate
Hardness 3
Calcite is the most common fl mineral. Depending on the activator, calcite may fl almost any color, but the most frequent fl is red or

pink resulting from manganese activation. Usually red fl calcites are best SW, but many are also good LW. Specimens are found that fl in shades of red varying from soft bluish pink to brilliant orange-red. The calcites that fl red usually have an extremely brief but brilliant orange-red ph SW.

Calcite is recognized by its low hardness and rhombohedral cleavage. It often forms white seam coatings in rock. Crystals in great variety are common in pockets, seams and geodes.

Well known localities include the zinc mines of Franklin and Ogdensburg, New Jersey which produce calcite that fl in nearly every shade of red. Langban, Sweden is another well known locality. Outstanding red fl calcite crystals have been found in Dumfrieshire, Scotland and Broken Hills, New South Wales, Australia. In Mexico excellent red fl calcite crystals have been found at San Louis Potosi, Charcas and Santa Eulalia. The mines at Santa Eulalia near Chihuahua City are well known for their red fl calcite crystal phantoms. Ludlow, California has also produced fl diamond shaped phantoms which resulted from the intermittent presence of manganese activator during the growth of the crystals. Calcite that fl red is found from time to time in mines and quarries almost everywhere. The well known calcite from Terlingua, Texas that fl and ph SW will often fl a beautiful pink LW.

CALOMEL
Mercurous chloride
Hardness 1 – 2
A secondary mercury mineral. Fl brick red. Occurs at El Doktor near Zimapan, Mexico. At Terlingua, Texas it was found in the mercury mines associated with Terlinguaite which fl yellow, and calcite which fl and ph blue.

CORUNDUM

Aluminum oxide
Hardness 9

Red ruby and other corundum will often fl deep red LW. This fl is usually brightest with a hot quartz (high pressure mercury arc) type of lamp. Synthetic ruby will also fl. Fl corundum is found in Madagascar and Myanmar (formerly Burma). In the United States red fl corundum is common in several localities of North Carolina and is also found in the limestone of northern New Jersey at Sparta, Newton and Ogdensburg.

EUCRYPTITE

Silicate of lithium and
Aluminum
Hardness 6

This uncommon lithium mineral fl a beautiful cerise red SW. It is an alteration product of spodumene and is sometimes found retaining the spodumene crystal form. Often associated with petalite which may fl white, fl eucryptite is found at Bikita, Zimbabwe (formerly Rhodesia) Africa; the Etta Mine, Keystone, South Dakota; and the Parker Mine, Stafford, New Hampshire. It was first noted as a spodumene alteration product at Branchville, Connecticut.

FLUORITE

Calcium fluoride
Hardness 4

Unusual dark purple fluorite crystals that fl dark red in LW and have been found at Mapimi, Durango, Mexico.

HALITE

Sodium chloride – common salt
Hardness 2 – 3

When suitable activators are present, halite will fl a pink to bright orange-red color. Amboy, California is one well-known locality for fl halite crystals. In some cases beautiful fl crystallizations have formed on sage brush where well brines have been allowed to evaporate on the desert.

SCAPOLITE

Silicate of aluminum, sodium and calcium
Hardness 5 – 6

Square prismatic scapolite crystals that fl red SW have been found in Quebec.

SPINEL

Magnesium aluminum oxide
Hardness 8

Occasionally spinel is found that fl brilliant red in LW. This fl seems more common in the red colored specimens.

Spinel is distinguished from most other minerals by its hardness.

TREMOLITE

Calcium magnesium silicate
Hardness 4 – 5

Tremolite that fl red in shades ranging from pink to a rich fire-red have been found in the talc mines of the Talcville - Balmat area of New York. The red fl material has often been found intergrown with tremolite that fl orange. These tremolites will fl both SW and LW. The red fl material is usually best LW while the orange fl tremolite is best SW.

WHITE, CREAM

ARAGONITE

Calcium Carbonate
Hardness 3 ½ - 4

Aragonite, with the same composition as calcite, but with orthorhombic rather than hexagonal crystal form, fl in many of the same colors as do the various calcites. Aragonite forms under a much narrower range of temperature and pressure conditions than calcite and is far less common.

Clusters of bright white fl LW aragonite crystal spikes have been found at San Luis Obispo, California. Fl aragonite SW spikes have been found in traprock at Deerfield, Massachusetts. Specimens from both of these localities exhibit a brief greenish-white ph. Some of the aragonite crystals from the sulfur mines of Sicily fl pink LW and white SW.

BARITE

Barium sulfate
Hardness 3 – 3 ½

Barite occurs in almost every color in natural light, but its fl is most commonly white, cream or yellow. It often has a cream or pale green ph. The great density of barite (specific gravity 4.5) is one of its distinguishing features and barite has been called "heavy spar" by miners.

An unusual barite with a very rich golden orange fl and ph both SW and LW has been found at Hot Springs, North Carolina.

Barite with a dull blue-white fl and also bright cream-white fl has been found at Franklin, New Jersey. The cream fl barite grains scattered in red calcite make very attractive specimens.

Barite crystals with white fl have been found at a number of localities. Palos Verdes, California has produced clusters of white cockscomb crystals that fl and ph. In the Badlands, South Dakota transparent brown crystals that fl white are found associated with yellow calcite crystals in pockets in large concretions. The calcite fl cream or white, best LW.

Excellent clusters of white fl barite crystals have been found at the Settlingstones Mine, Fourstones, England.

BRUCITE

Magnesium hydroxide
Hardness 2 ½

This soft mineral is often platy or fibrous in form and frequently fl bright blue-white. Fl brucite has come from the Tilly Foster Mine, Brewster, New York and from Woods Chrome Mine, Texas, Pennsylvania.

CALCITE

Calcium carbonate

Hardness 3

Calcite is the most common fl mineral and it reacts in a wide variety of colors. The Red-Pink descriptive section has more information on fl calcite.

Calcite that fl white is not unusual and is particularly common in caves where the stalactites and stalagmites will frequently fl white. These calcites will usually fl both LW and SW, but they are generally best LW. A brief cream-white or green-white ph is usual.

Fine crystallized calcites that fl white are found at Santa Eulalia, Chihuahua, Mexico and Bound Brook, New Jersey. Calcite crystals that fl cream are found in cavities in concretions in the Badlands of South Dakota.

Calcite or aragonite in the form of travertine and marble will often fl white.

CELESTITE

Strontium sulfate

Hardness 3 – 3 ½

Celestite crystals that fl white or blue-white have been found associated with calcite and sulfur in the sulfur mines of Sicily. These colorless crystals fl both LW and SW and have a greenish-white ph. Blue celestite crystals from Portage, Wood County, Ohio have shown a similar white fl and a strong but brief green ph that quickly fades to a dim white afterglow.

COLEMANITE

Hydrated calcium borate

Hardness 4 – 4 ½

One of the water insoluble minerals found in the Borax deposits of California at Death Valley, the Calico district, the Kramer district and on Frazier Mountain in Ventura County. Colemanite occurs in white and transparent crystals. It usually fl white or cream color both SW and LW and generally has some ph.

DEWEYLITE
Magnesium silicate
Hardness 2 – 3 ½

Deweylite is a soft mineral close to serpentine in composition. It is sometimes called Gymnite. Deweylite that fl white both LW and SW has been found in the Maryland-Pennsylvania serpentine localities. Cedar Hill, Pennsylvania has produced waxy masses of crumbly deweylite with a good white fl.

DIOPSIDE
Silicate of calcium and magnesium
Hardness 5 – 6

The diopside variety of pyroxene is sometimes found in small fl grains and masses in calcide. The fl ranges from white to blue-white.

Fl diopside is found at Franklin, New Jersey and Newcomb, New York.

DUMORTIERITE
Basic aluminum borosilicate
Hardness 7

The fibrous violet-red dumortierite from Dehesa, California fl blue-white SW.

FLUORITE
Calcium fluoride
Hardness 4

While blue is the most common fl response of fluorite, white or cream fl is not unusual. Both the blue and the cream fl materials are usually fl both SW and LW but are brightest LW.

An outstanding locality for bright cream fl fluorite is the limestone quarry at Clay Center, Ohio. Large brown cubic fluorite crystals have been found there lining pockets in the limestone. Crystals with faces as much as four to five inches across and perhaps even larger have been found at Clay Center. Smaller fl fluorite crystals have been found in other quarries in the area.

Fluorite with a good white fl has been mined in considerable quantity at Marion, Kentucky. Fluorite with white and cream fl and ph has been found in Mexico.

HYDROZINCITE

Basic zinc carbonate

Hardness 2 – 2 ½

This secondary zinc mineral usually fl blue-white SW and is further described in the Blue section.

PETALITE

Lithium aluminum silicate

Hardness 6 – 6 ½

The lithium mineral petalite is often found in association with the uncommon fl lithium ore eucryptite. The petalite fl white SW and LW, while the eucryptite fl cerise red SW only. Fl petalite is found in considerable quantity in association with the eucryptite ore from Bikita, Zimbabwe, Africa. It is often found in minor amounts associated with the eucryptite from other localities.

SCHEELITE

Calcium tungstate

Hardness 4 ½ - 5

This important ore of tungsten is one of the few minerals that is always fl. It reacts brightly to SW and normally does not fl at all LW. The fl or scheelite ranges from yellow to white to blue-white. Further information of fl scheelite will be found in the Blue section.

STOLZITE

Lead tungstate

Hardness 2 ½ - 3

Stolzite is an uncommon secondary mineral usually found in the oxidized zone of ore bodies containing tungsten minerals. It usually fl greenish-white SW. Found in the United States at

Southampton, Massachusetts; in Arizona in scheelite deposits south of Tombstone and near Dragoon; near Lucin, Utah; and at the Wheatley Lead Mines, Chester County, Pennsylvania.

TALC
Magnesium metasilicate
Hardness 1 – 1 ½
Pure talc is number one on Moh's scale of hardness and distinctive in that it is one of the few minerals that can readily be scratched with the fingernail.

Much of the talc from the Balmat and Talcville area of New York state will fl cream-white or pale greenish-white SW.

WITHERITE
Barium carbonate
Hardness 3 – 3 ½
Most of the twinned witherite crystals from the fluorite mines at Rosiclare, Illinois fl bright blue-white LW and SW.

THE FLUORESCENT MINERALS OF FRANKLIN, NEW JERSEY

APATITE
Fluoride phosphate of calcium
Hardness 5
Occurs in limestone outside the ore body. May fl gray-green SW.

ARAGONITE
Calcium carbonate
Hardness 3 ½- 4
Found as coatings and as sharp pointed crystals which formed in cavities. Fl white or cream. Best LW.

AXINITE
Boro-silicate of aluminum and calcium
Hardness 6 ½ - 7

The lighter colored axinite from Franklin has deep red fl SW and also some fl LW. A long lived ph is sometimes observed with an unfiltered light.

BARITE
Barium sulfate
Hardness 3 – 3 ½

Fl gray-white. Sometimes bluish or bright cream white. Often associated with fl calcite in showy fl specimens. Usually in scattered grains, sometimes in masses, seldom in distinct crystals. Fl SW.

BARYLITE
Silicate of beryllium and barium
Hardness 6 – 7

A rare mineral. Fl blue-white SW.

CALCITE
Calcium carbonate
Hardness 3

The most common fl mineral of Franklin, the manganese activated calcite fl SW in various shades of pink and orange-red. Most specimens fl slightly LW but calcite that fl brightly LW has at times been found. The calcite of Franklin and Ogdensburg has a very brief but intense ph. This ph can be easily observed in a sphere cut from the fl calcite. If the SW light is shown on the back side of the sphere as it is spun on a vertical axis, it will appear as if the orange-red ph is dragged around the sphere. Associated willemite specks will often lend green streaks to the ph color.

CALCIUM LARSENITE
Silicate of zinc, lead and calcium
Hardness approximately 5

A rare mineral found only at Franklin, New Jersey, calcium larsenite fl brilliant chartreuse SW and dull yellow LW. Often associated with green fl willemite, blue fl hardystonite, red fl calcite and non-fl black Franklinite to produce the world's most colorful fl specimens.

CLINOHEDRITE
Silicate of calcium and zinc
Hardness 5 ½

Normally a thin coating that fl golden brown SW. Usually ph. Fl weak LW.

CORUNDUM
Aluminum oxide
Hardness 9

Red grains and crystals in limestone from Ogdensburg. FL deep red LW.

DIPOSIDE
Silicate of calcium and magnesium
Hardness 5 – 6

Blue-white fl grains have been found in the Franklin limestone. Sometimes associated with fl norbergite.

FLUORITE
Calcium fluoride
Hardness 4

Brownish-red fluorite usually associated with Franklinite will often fl and ph blue-green both SW and LW. Reaction is best on freshly broken surfaces.

HARDYSTONITE
Basic zinc carbonate
Hardness 2 – 2 ½

White, gray or flesh colored mineral with blue-violet SW fl difficult to distinguish from visible light passed by the lamp filter. Often associated with other fl minerals in spectacular color combinations.

HYDROZINCITE

Basic zinc carbonate

Hardness 2 – 2 ½

Occurs as thin powdery blue-white SW fl coatings on calcite and other minerals. Often found on the old dumps where it is an alteration product of zincite.

An interesting find of hydrozincite was made when Lake Hopatcong in northern New Jersey was drained for cleaning. During the early history of zinc mining at Franklin and Ogdensburg, the ore was barged across Lake Hopatcong en route to the smelter in Newark. Inevitably a portion of the ore fell off the barges into the lake. Collectors of fl minerals had a field day when the lake was drained. Among the materials found were specimens of blue-white fl hydrozincite that had formed over the years underwater, from the zinc ore that originally fell into the lake.

MANGANAPATITE

Fluoride-phosphate of calcium and manganese

Hardness 5

Sometimes mistaken for svabite. Occurs as gray-green masses and crystals that fl buff-brown SW.

MARGAROSANITE

Silicate of lead, calcium and manganese

Hardness 2 ½ - 3

Rare mineral found as pearly plates and scattered grains that fl brilliant blue-white SW. It has been found intermixed with axinite in pink fl masses.

NORBERGITE

Basic fluosilicate of magnesium

Hardness 6 – 6 ½

Found as scattered grains and crude crystals in limestone. Usually dark honey yellow in color but sometimes light, almost white. Fl SW ranging in color from bright yellow for the lighter colored specimens to dull buff for the darker materials. Makes attractive specimens when associated with blue-white fl diopside.

PECTOLITE

Hydrus silicate of calcium and sodium

Hardness 5

Pectolite is one of the less common fl minerals of Franklin. It occurs usually as pinkish or dull gray fibrous masses and fl buff orange SW. Pectolite has a bright momentary orange ph.

PHLOGOPITE

Silicate of magnesium, potassium and aluminum

Hardness 2 ½ - 3

Some of the specimens of phlogopite mica fl dull golden brown SW.

SPHALERITE

Zinc sulfide

Hardness 3 ½- 4

Found at Franklin and more commonly at Ogdensburg, as scattered grains and occasionally as veins. Sphalerite fl golden orange, best LW, and usually has a strong ph. Sometimes fl blue, often as blue fl and ph edges on the orange fl grains. The blue ph is usually brighter and shorter lived than the orange ph.

SVABITE

Fluorite-arsenate of calcium

Hardness 4 – 5

The arsenic apatite, svabite, is distinguished from manganapatite only by tests for arsenic content. The fl SW varies from bright golden brown in the light, nearly white colored svabites, to dull brown in the gray and green specimens.

TREMOLITE

Silicate of calcium and magnesium

Hardness 4 – 5

Found as slender light gray crystals in the local limestone. Fl dull greenish-white SW.

WILLEMITE

Zinc silicate

Hardness 5 ½

The brightest fl of the Franklin minerals is seen in willemite. The fl is normally yellow-green and rarely yellow. The brightest fl is usually seen in the material that is apple green in natural light. Fl best SW, sometimes good LW. The dark brown and red willemite fl little if any LW and has a dull fl SW. Some of the white willemite, especially that found at the Parker shaft as radiating white crystals, has a very bright and long lived green ph.

Willemite is found usually in rough grains and crystals. Occasionally the crystals, especially the small ones, are clear and sharp.

WOLLASTONITE

Calcium metasilicate

Hardness 4 ½ - 5

One of the most prized of the Franklin fl minerals, wollastonite is rare and brilliantly fl. The daylight color is gray or white, the fl SW is brilliant orange that in some specimens grades to brilliant orange-yellow. Fl LW is weak. Nondescript in daylight, few specimens of wollastonite were saved when solid masses were mined in the 1930s. A quantity of fl wollastonite specimens consisting of large scattered grains in fl calcite were obtained from the mines in more recent years. This latter material usually had associated barite that fl blue-white. Some of the earlier material was associated with green fl willemite making truly spectacular fl specimens.

Versalume™ by Raytech

The most versatile & powerful portable ultraviolet lamp on the market today. new design allows use with batteries or 115V a/c adapter

Raytech's newly designed Versalume series offers a lightweight compact construction designed for use with four "AA" batteries or with a 115V A/C adapter. This popular portable boasts 33% more UV output than competition models and incorporates Raytech's exclusive lifetime filters. *Story of Fluorescence* included. Philatelic models include view box. All models offer a full 4 watts of UV power. CE

PP-FLS (Longwave/Shortwave) 115v, 60Hz	#10-020
PP-FS (Shortwave) 115v, 60Hz	#10-022
PP-FL (Longwave) 115v, 60Hz	#10-024
PP-FLS (Philatelic Use Only) 115v, 60Hz	#10-021
Philatelic LW Lamp (Philatelic Use Only) 115v, 60Hz	#10-026
Philatelic SW Lamp (Philatelic Use Only) 115v, 60Hz	#10-028
Versalume PH Kit (Philatelic Use Only) 115v, 60Hz	#10-030
PP-FLS (Longwave/Shortwave) (230v, 50Hz)	#10-012
PP-FS (Shortwave) (230v, 50Hz)	#10-013
PP-FL (Longwave) (230v, 50Hz)	#10-014

Raytector 5-2

RAYTECH'S RAYTECTOR 5-2 Offers both standard A/C operation & battery power for portable use and has a full 12 watts of power.

Raytector Portables have an internal, rechargeable lead acid battery eliminating replacements. One full charge of 24 hours gives 5 to 7 hours of battery operation. All models are equipped with built-in chargers that plug into wall outlets for intermittent or continuous recharging. Raytech's new dual tube models can operate with either one or both tubes simultaneously. Single tube operation extends battery life while double tube operation substantially increases the output intensity to a full 12 watts. Each lamp comes with Raytech's exclusive lifetime filters and A/C adapter.

DESCRIPTION	**115v/60Hz**	**230v/50Hz**
R5-FLS (Longwave/Shortwave)	#10-062	#10-066
R5-FS (Shortwave)	#10-063	#10-067
R5-FL (Longwave)	#10-064	#10-068

Mid-Wave Conversion Kit #10-069
(Allows you to convert existing Model R5-FS by changing (2) tubes inside).
Note: 230V/50Hz Models are not for A/C operation. Only the recharging unit is.

Raytector 5-2 VB Adapter

This durable Plastic adapter allows for easy conversion of the current Viewbox so that the Raytector 5-2 portable/rechargeable Ultraviolet Lamp can be adapted to the viewbox in seconds! #12-041

Raytech View Box

For convenient, light-shielded fluorescent examination. Ideal for classroom and scientific use in chromatography and mineral inspection as well as identification of stamps, dyes and chemicals. Models VB-7 is designed for use with LS-7 lamp while VB-8 uses LS-88. Lamp can be easily removed for separate use. VB-7 #12-014, VB-8 #12-015

Ultraviolet Applications

DYES AND MARKERS
Automotive and industrial leak detection, DNA enhancement dyes
Fingerprint enhancement powders, Ground and surface water tracers
Invisible criminal tagging dyes, Theatrical make-up and staging
Invisible personal property identification markers
Postal stamp inks, Social event admission stamp markers
LOCATION AND IDENTIFICATION
Forgeries and repairs of artwork, antiques, and collectibles
Fungi, ringworm, bacteria, urine, and spermatozoa
Pollutants and arson accelerants; rodent control
Scorpions and other anthropods and insects
Valuable ores, minerals, gems, and hydrocarbons
UV RADIATION AS A TOOL
Adhesive curing, DNA and other molecular bond breakdown
Sanitation and germicidal

CAUTION

Be careful to limit exposure of your eyes to shortwave ultraviolet rays. These rays can “sunburn” your eyes and cause uncomfortable irritation. You should not look into a shortwave lamp when it is turned on.

Versalume Verification Kit

Use the Versalume Verification Kit to detect repairs and verify authenticity of valuable collectibles. Ultraviolet light reveals the differences between the original and later repairs. It detects repair pigments, glues, epoxies and paints on many collectibles such as china, glassware, pottery, paintings and various antiques. *Kit includes* 1 Versalume LW-10-026, and 1 security marking pen.

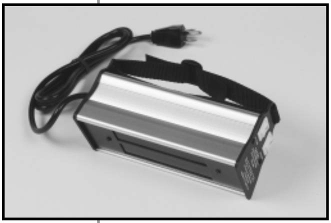
VV-1 Kit #12-035
Fluorescent Security Marker #12-050

Model 4

The LS-4 still proves to be the most popular lamp in the Raytech Compact Ultraviolet line today. This compact and low cost lamp offers everything one can expect and is simplistic to use. This model is also featured as our "Select-O-Wave" model which contains a sliding wavelength selector allowing you to either use longwave, shortwave or both simultaneously from the same tube. This lamp also includes *The Story of Fluorescence*.

	115v/60Hz.	**230V/50Hz**
Model LS-4CB Longwave/Shortwave	#10-074	#10-075
Model SW-4CB Shortwave	#10-076	#10-077

Model 7



The compact, easy-to-use lamp that offers everything for complete lab and educational use. Also a favorite with mineral collectors and philatelists.

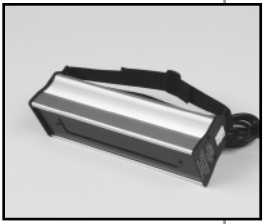
The LS-7 is actually two independent lamps in one case. The LS-7 has two momentary switches, for both shortwave, and longwave to be on. Each wavelength produces 4 watts of power. Set includes lamp plus The Story of Fluorescence.

Model LS-7CB Longwave/Shortwave 115v/60Hz #10-082, 230V/50Hz #10-083

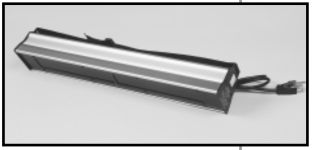
Model 8 Lodestar

Our most powerful hand-held longwave lamp features large filter area, built-in handle and a full 6 watts of power. The Model LW-8 comes complete in a rugged metal housing with convenient carrying strap for easy handling. This lamp also includes The Story of Fluorescence.

Model LW-8L 115v/60Hz #10-090, 230v/50Hz. #10-091



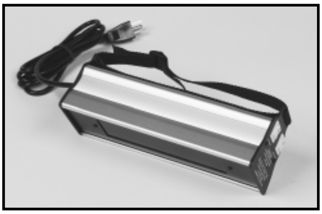
Model 18



These economical single tube 15 watt display lamps also feature Raytech's exclusive lifetime filter. Model LS-18CB has single switch and emits LW at one end, and SW at the other. At 12", it covers 2 ft. x 2-1/2 ft. display area. This lamp also includes *The Story of Fluorescence.* 115v/60Hz

Model LS-18CB	Longwave/Shortwave	#10-098
Model SW-18CB	Shortwave only	#10-102
Model LW-18	Longwave only	#10-100

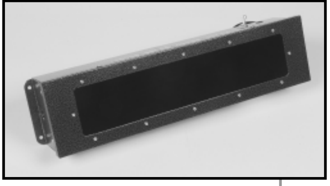
Model 88 Superstar



The expert's favorite tube model now even better with Raytech's exclusive lifetime filter. All fluorescence examination is simplified and enhanced with this versatile and easy-to-use lamp. An intense flood of longwave or shortwave ultraviolet is yours at the flick of a switch. Powerful Superstar delivers the shortwave or longwave output of two ordinary lamps. This lamp is manufactured with an anodized brushed aluminum housing as well as a convenient carry strap for easy handling. If you're looking for the best compact hand-held LW/SW light, this is it! This lamp also includes *The Story of Fluorescence*.

Model LS-88CB Longwave/Shortwave 115v/60Hz #10-106, 230v/50Hz. #10-107

Display Model 218



Two fifteen watt tubes and large 3" x 15" filter area for brilliant displays. At 18" covers 2' x 4' display area. The LS-218CB has separate longwave and shortwave tubes and filters. Separate switches permit separate or combined wave length selection. Full 30 watts of power covers 3' x 5' at 20".

		115v/60Hz	**230v/50Hz**
Model LS-218CB	Longwave/Shortwave	#10-110	#10-111
Model LW-218	Longewave Only	#10-112	#10-113
Model SW-218CB	Shortwave only	#10-114	#10-115
Model MW-218	Midwave only	#10-116	#10-117

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