Ultraviolet Light and its Use with Fluorescent Minerals

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It is interesting to consider that while man has sought color in minerals for tens of thousands of years, one of the most brilliant and dramatic color phenomena in minerals has been unknown until recently. This is the phenomenon of fluorescence. Of the roughly 4,200 mineral species thus far identified, 566 of them (from more than 6,500 localities) are reported as fluorescent in The Henkel Glossary of Fluorescent Minerals, published in 1989. Some of these fluorescent species (e.g., calcite, hyalite opal) are widespread, while others (e.g., agrellite, benitoite, esperite, tugtupite) are found in only one or a few places in the world.

Fluorescence is the visible light produced by certain minerals when they are illuminated by the invisible light rays of an ultraviolet (UV) light source. The term was coined in 1852 by Sir George Stokes (1820-1903) after observations on fluorite from Alston Moor, Cumberland, England, by analogy with the term "opalescence" already attributed to opal. Fluorescence occurs as "activator" atoms in the fluorescing mineral absorb UV, thereby transferring an electron from a lower vibration band to a less-stable upper (i.e., higher-energy) vibration band. As a result, the electron is thrown into increased vibration which, in turn, transfers energy to neighboring atoms. Thus, the energized electron gradually gives up much of its new-found energy as heat and gradually slips down to the lower edge of the upper vibration band. Next, the electron gives up all, or nearly all, of its remaining surplus energy derived from UV radiation in one burst, in the form of visible light, while returning to its original "ground state." This, then, is fluorescence. In accordance with Stokes' law of fluorescence, the light produced must be of lower energy (i.e., longer wavelength) than that taken in earlier from the absorbed UV, with the remainder of the energy dissipated as heat. Stokes' law, then, allows a blue light to produce a red fluorescence, but not vice-versa. Some minerals fluoresce with such intensity that the effect is noticeable in sunlight. The fluorescent green of some willemites, the blue of some fluorites, and the red of some rubies in daylight is related to excitation by solar UV.

Phosphorescence is the afterglow produced when a UV lamp is held over a fluorescent mineral and is then turned off or moved away. Phosphorescence results from atomic processes that prevent electrons energized by UV from rapidly discharging their energy, usually involving "traps" of their energized electrons at some location from whence they cannot return quickly to their low-energy state. This can happen as a result of crystal defects, missing atoms, or substitution of foreign "impurity" atoms in the crystal of the mineral. A dark-adapted eye has been shown to be able to detect phosphorescence in fluorite from Trumbull, Connecticut for an amazing 36,000 hours after exposure. Phosphorescence is generally more prominent under SW than LW.

To understand fluorescence, it is useful to review the electromagnetic spectrum. Visible light, containing all of the colors of the rainbow, extends from violet at a

wavelength of 400 nm to red at 750 nm. Light with wavelengths longer than 750 nm is termed infrared light. We cannot see this light, but we can sense it as heat, and we generally seek shade in the hot summer sun to avoid over-exposure to it. Light with wavelengths shorter than 400 nm is termed ultraviolet (UV) light. We can not see (NOTE: while normal vision extends down to about 380 nm, the seeing capabilities of some individuals, mostly youngsters, have been reported to extend down to almost 310 nm) nor feel this light, but it may have biologic effects, depending on its wavelength.   Light with wavelengths between 350 nm and 400 nm is termed long wave (LW) UV light; it is commonly called "black light" after the readily available "black-light-blue" (BLB) tubes and bulbs popular with kids who use them to illuminate fluorescent "pop art" posters as well as teeth, fingernails, many paints, and some fabrics. LW UV light has no known deleterious effects on either the skin or eyes. Light with wavelengths between 300 and 350 nm is termed mid wave UV light. Light with wavelengths shorter than 300 nm is termed shortwave (SW) UV light. UV-A refers to wavelengths from 315 to 400 nm, while UV-B refers to wavelengths from 280-315 nm, and UV-C refers to wavelengths from 200 to 280 nm. SW UV in modest amounts can assist the body in absorbing Vitamin D and promoting suntan (UV-A), and can also help to create a sterile environment by killing bacteria (UV-C). However, overexposure can cause nuclear cataracts (UV-A), painful sunburn (UV-B), and increase the risk of skin cancer (UV-B>UV-A). One should never look directly at the SW UV light, and should also be aware that some specimens, particularly polished or metallic ones, may reflect UV light back at the collector, even with the lamp pointed away. With prolonged, unprotected exposure of the eyes to SW UV light, temporary sunburn of the eyes can result 6 to 8 hours after exposure, generally manifesting as weepy eyes with a sensation of sand in them on blinking. Fortunately, eyeglasses and goggles provide complete protection from SW UV on direct viewing; LW UV, in contrast, can pass easily through most glass and plastics.

Fluorescent mineral enthusiasts are generally concerned with two UV wavelengths: SW and LW. SW lamps produce UV radiation at 253.7 nm, while radiation from LW lamps has two different wavelengths one that peaks about 351 nm (called long wave three fifty, LW350) and the other at about 368 nm (called long wave three seventy, LW370). Some minerals fluoresce only under SW or one of the LW wavelengths, but not both, SW and LW350 or LW370. For example, most scheelite fluoresces only under SW light; while most ruby corundum fluoresces only under one of the LW wavelengths (it usually is brighter under LW370). More commonly, minerals will fluoresce under both SW and LW, usually in the same color or nearly so, though a very high percentage of them fluoresce brighter under SW. Less commonly, minerals may fluoresce different colors under SW and LW light. Examples of the latter include: calcite from the mercury mines of Terlingua, Brewster County, Texas (fl. blue, SW & fl. pink, LW); sodalite, var. hackmanite, from Bancroft, Ontario, Canada (fl. red, SW & fl. orange, LW); tugtupite from Ilimaussaq, Greenland (fl. cherry red, SW & fl. deep orange, LW); and yttrofluorite from the Globe pegmatite in Rio Arriba County, New Mexico (fl. bright lemon yellow, SW & fl. blue, LW).

The newest UV wavelength is Medium Wave (MW) sometimes called Middle Wave. It has a peak wavelength at about 312 nm. Many calcites will fluoresce brighter

under MW and a few minerals will only fluoresce under MW (e.g., minehillite from Franklin, NJ and calcite from the Cadman Quarry in Monroe, WA).

The earliest source of SW and, to a lesser extent, LW UV was the iron arc, or iron spark gap machine, used as early as 1903. Subsequently, numerous innovations in the production of UV tubes and filters have produced stronger and more efficient equipment. Production has been spearheaded by Ultra-Violet Products, Inc., of San Gabriel, California, (now UVP, Inc. in Upland, CA) and Raytech Industries of Middletown, Connecticut. Currently, the strongest portable lamps, the *SuperBright II* 3000 series models, weigh less than 2 pounds each and are produced by UV SYSTEMS, Inc. of Renton, Washington (see their website: www.uvsystems.com These lights feature "U"-shaped hot-cathode quartz bulbs and high-efficiency reflectors and currently retail for about $449.00 depending on the model (plus S & H). Portable UV lights in the past have utilized lantern batteries for power; newer models like the *SuperBright IIs* are offered with rechargeable 12V lead-acid "fanny pack" batteries which can be worn around the waist.

Since most fluorescent minerals are white or light in color, they might be expected to reflect appreciable amounts of the visible light produced by the lamp. By contrast, the conversion of UV to visible light by fluorescent minerals is very inefficient, resulting in only a low-output intensity. Thus, without a suitable filter, reflected light would overwhelm the visible light produced by fluorescence in all but the most intensely fluorescent minerals. The production of such a filter, particularly for the SW lamp, requires a meticulous balance of metal oxides. The BLB LW UV tubes are made of glass which is colored purple to act as a built-in filter, albeit an inefficient one, emitting a significant amount of visible blue light along with the UV.

SW filters are prone to a process called "solarization," which gradually reduces the light transmitted through the filter at a given wavelength, and should generally be replaced after about 6,000 hours of use (about 5 years of heavy use, 3 years of medium use, and 1 years of heavy use), or sooner in areas of high humidity. Hoya Optics U-325C filters have the lowest solarization rates of any SW filter tested in a 1990 study. With LW filters, solarization is negligible, but the special phosphor in LW lamps deteriorates over time in a process called "lumen depreciation," and these lamps gradually lose their effectiveness long before they burn out. Although SW and LW lamps are generally rated by the manufacturer to last 4,000 to 10,000 hours, their useful life spans are probably considerably less, and it is recommended that they be replaced every 7-8 years with infrequent use, every 5-6 years with medium use, and every 3-4 years with heavy use.

"Dual-band" UV lamps containing both a SW and a LW tube are generally preferred for field use and for reviewing dealers' stock in stores and at mineral shows. A single SW filter is satisfactory for both bands. Most of these lamps allow for either band to be used separately, or for both to be used simultaneously. However, if investigation is to be confined to an area in which either SW- or LW-fluorescing minerals predominate, a single-band portable may be preferable.

Generally, pure minerals do not fluoresce. Exceptions include the uranyl $(UO_2)^{2+}$ group which accounts for the characteristic yellow-green fluorescence of autunite and other secondary uranium minerals; the tungstate $(WO_4)^{2-}$ group which accounts for the bluish fluorescence in scheelite; the molybdate $(MoO_4)^{2-}$ ion accounting for the pale yellow

fluorescence in powellite; and the lead (Pb^{2+}) ion supplying the yellow fluorescence in cerussite and anglesite; such minerals are said to be "self-activated." Most often, though, fluorescence is made possible by an activator—a "foreign" element that introduces the necessary energy levels into the mineral to allow fluorescence. The most important activators are manganese (Mg^{2+}) and lead (supplying red or orange fluorescence to anthophyllite, apatite, axinite, benstonite, calcite, clinohedrite, halite, margarosanite, pectolite, sphalerite, svabite, tirodite, tremolite, walstromite, and wollastonite, as well as yellow fluorescence to esperite, and green fluorescence to willemite), uranium (supplying green fluorescence to adamite, apophyllite, aragonite, calcite, gyrolite, hyalite, and quartz, var. chalcedony), and the rare-earth (RE) elements, especially europium (supplying blue to violet fluorescence to apatite, calcite, danburite, microcline, and especially fluorite). Other activators include trivalent chromium (Cr^{3+}, which supplies deep red LW fluorescence to corundum, var. ruby, spinel, uvarovite, and kyanite); the disulfide ion (S^{2-}, supplying yellow fluorescence to scapolite and orange fluorescence to sodalite); mercury, supplying orange fluorescence to calomel; and probably copper and silver (with "co-activators"—see below). The presence of activators helps to explain why a single mineral, especially when found in different locations, can fluoresce in different colors; fluorite is a good example of this. Specimens of fluorite from the Weardale mining district in Durham, England are famous for their bright, violet-blue fluorescence. Blocky fluorite crystals from Clay Center, Ohio fluoresce yellow, while lumpy masses of the mineral from Fremont County, Colorado fluoresce deep green, and masses from the Ojuela mine in Mapimi, Durango, Mexico fluoresce a deep red color. Other naturally occurring fluorites are reported to fluoresce white, cream, pink, and orange (under either SW or LW), probably related to the wide variety of RE activators in fluorites. Similarly, specimens of sphalerite have been reported to fluoresce blue, green, yellow, orange, and red. This inconsistency of fluorescent response in a given mineral undoubtedly helps to explain why the property of fluorescence has not become as important to mineralogists as other more intrinsic identifying properties such as hardness, cleavage, and specific gravity.

Occasionally, a "flash" of initial color can be produced by rapidly passing a UV lamp over a specimen, subsequently overwhelmed by the more sustained fluorescent color usually associated with that mineral. The presence of flash indicates two distinctive fluorescences, each usually due to a separate activator. This effect is seen particularly well in agrellite from the Kipawa River in Quebec, Canada and in various calcites, most notably those from Terlingua, Texas. An orange flash generally denotes the existence of manganese acting as an activator.

The presence of a potent activator such as Mg^{2+} may not be sufficient to induce fluorescence, however. A second impurity, one that can absorb UV radiation and transfer some of the absorbed energy to the activator ions to optimize their performance, may be necessary. Such additional impurities are called coactivators, or sensitizers. In the case of manganese, the coactivator is usually lead (Pb^{2+}). As with activators, the list of known and potential coactivators is a long one, including aluminum, antimony, arsenic, bismuth, copper, gallium, indium, lead, manganese, thallium, tin, and various RE elements.

Other elements effectively prohibit fluorescence in the minerals that contain them, even in minute amounts. The most prominent "quenchers" of fluorescence are divalent

iron (Fe^{2+}), cobalt, and nickel, and to a lesser extent, copper. Of the 566 mineral species reported as fluorescent in the Henkel Glossary of Fluorescent Minerals, only four contain nickel or cobalt in their chemical formulas. Nickel, in concentrations of only 1 part per million in sphalerite results in a marked decrease in brightness, and at slightly higher concentrations quenches the fluorescence of willemite. UV can stimulate charge-transfer transitions, movements of electrons from one ion to like or unlike neighboring ions. In the process, the majority of the absorbed energy is converted into heat, leaving insufficient energy available to the activator to allow fluorescence to take place. However, the condition of quenching is really quite complex. Copper, for example, quenches fluorescence in most minerals, including several of the uranium-based minerals, yet it can cause fluorescence in sphalerite, and the mineral marshite (CuI) fluoresces bright red under LW, despite containing 1/3 copper by weight. In addition, trivalent chromium (Cr^{3+}) and RE ions, frequently effective activators are prone to self-quenching, also known as concentration quenching. Thus, light emitted by some of these ions is partially reabsorbed by other like ions in the mineral, thereby limiting the overall intensity of the fluorescence. Thresholds for concentration quenching are <1% for most Cr^{3+}-activated minerals and on the order of only a few tens of a percent for minerals activated by RE ions. Finally, thermal quenching occurs in all fluorescent systems; if ambient temperature is raised high enough, fluorescence will disappear. This occurs as a result of increased molecular vibrations in the mineral structure interacting with the activator and carrying off some of the excitation energy as heat. Thus, titanium (Ti^{4+})-activated fluorescence is usually thermally quenched at room temperature, with fresnoite and benitoite representing exceptions to this generality.

      Another common cause of fluorescence is distortions in the ideal crystal structure of various minerals, known collectively as point defects. Among these are Frenkel defects, which are ions in abnormal locations in the crystal structure; Schottky defects, which are vacancies due to missing ions, and interstitial defects, which are impurity ions in crystal lattice sites not normally occupied. Such defects alter the normal absorption and dissipation of light energy within and near the structurally imperfect parts of the crystal. Such point defects, commonly causes of daylight color in minerals that would otherwise be colorless or white, are also associated with yellow-green fluorescence in diamond, blue fluorescence in sphalerite, many cases of white fluorescence in calcite, and with fluorescence in some fluorite and in various sulfate minerals.

      Fluorescent mineral collecting is most effectively done in the dark. Under optimal conditions, the most intensely fluorescent minerals, such as autunite, scheelite, hyalite opal, and hydrozincite, may be visible 40 to as far as 75 feet away with the most powerful modern UV lamps. In fact, Robbins reports some green fluorescence in Franklin willemite at a distance of 130 feet! However, given the absence of light on moonless nights, special precautions must be observed. Collecting should generally be confined to areas which have been thoroughly scouted by daylight, and important landmarks should be committed to memory. The locations of any mine shafts or air shafts are particularly important; the location of large cacti and quarry benches and ledges should also be noted. Beware that scorpions fluoresce—usually green, occasionally white. It's a good idea to wear heavy gloves as a beginning collector, or at least to be very wary of what you're about to pick up.

The buddy system is particularly important in night-collecting. A good flashlight and a compass or GPS locator are very handy. It is a good idea to mark all tools and collecting bags/buckets with fluorescent tape so that they can be easily spotted with the help of the UV lamp.

Measurements on certain specimens of blue-fluorescing fluorite, yellow-fluorescing meionite (marketed as "wernerite"), orange-fluorescing tremolite and wollastonite, and red-fluorescing halite, calcite, axinite, and ruby reveal their colors of fluorescence to be nearly "saturated," i.e., pure. Similarly, the green fluorescence of some willemite and various uranium minerals is more pure than many commonly used green inks and dyes. The common practice of viewing fluorescent minerals in pitch-darkness furthers the suggestion (probably false) that the fluorescent minerals are, as a group, somehow brighter and more intense than ordinary colors. The brightest of the fluorescent minerals are generally said to be willemite from Franklin, New Jersey; hyalite opal; and meionite, var. "wernerite," from southern Quebec, Canada.

After observing a collection of numerous fluorescent minerals, one might be tempted to ask, "Why don't all minerals fluoresce?" Actually, there are several explanations for this. First, UV does not penetrate into some minerals, such as the native metals and many of the sulfides and oxides with a metallic luster in visible light. Secondly, light absorption in other minerals causes the excited electron to drop from the upper band to the lower band and give up all its surplus energy in collisions with neighboring atoms, i.e., heat, without being available to the activator to radiate visible light. Occasionally this occurs as a result of "quenchers" of fluorescence, described above. Thirdly, still other minerals are "transparent" to UV light, to the extent that even UV cannot provide the necessary energy to raise the mineral's electrons from the lower band to the upper band; this applies particularly to transparent or very light-colored minerals. Finally, some minerals may fluoresce to produce light in the infrared or UV portions of the electromagnetic spectrum, both of which are invisible to the human eye.

Many mines in the U.S., including the Franklin, NJ workings of the New Jersey Zinc Company and various tungsten workings, have employed powerful UV lamps over their "picking tables" in the past to permit hand-sorting of willemite and scheelite ores, respectively, in order to upgrade returns and save time, water, reagents, and wear on milling machinery. Freshly drilled core samples have been examined for UV fluorescence and phosphorescence, to aid in the identification of the various layers sampled; this practice has been particularly helpful in identifying borates in core samples at Searles Lake, California. Oil companies have also lamped the cores of drilling wells, looking for the bluish fluorescent glow emanating from petroleum or asphalt deposits.

Ultraviolet testing of gemstones under SW and LW has been one of the classical tests performed by gemologists, along with the determination of refractive index and specific gravity. In fact, the classification of diamonds into Types Ia, Ib, IIa, and IIb was originally based on their transparency under UV; today, this classification is based on infrared absorption, which provides more details about the type of impurity present. Fluorescence testing can help to identify the gem species to which a particular stone belongs, e.g., to differentiate rubies from garnets and tourmaline. UV response can also help to distinguish natural diamonds, rubies, and emeralds from their synthetic

counterparts. To help separate Ramaura synthetic rubies from natural stones, their inventor, Judith Osmer, has doped them with a RE element that shifts their fluorescence from red to orange. Many assembled stones, i.e., those composed of several materials put together to simulate the appearance of a more valuable stone, are effectively detected using UV light. In addition, UV examination can help to identify oils or resins used to hide surface-reaching fractures in natural emeralds, as well as organic dyes used to imitate lavender jadeite. UV response has also been used occasionally as an indication of a gemstone's geographical origin; hence, an apricot fluorescence under LW is characteristic of blue and yellow sapphires originating in Sri Lanka. Similarly, some colorless diamonds show a strong blue fluorescence in visible light and are called "Jagers," because they have been found preferentially in the Jagersfontein mine in South Africa. Finally, fluorescence in visible light can substantially increase the value of some rare diamonds. Such is the case with the previously described "Jagers" and with another group called the "green transmitters" or "chartreuse diamonds," which are colored green by their green fluorescence excited by visible light.

Fluorescent mineral collecting has enjoyed two commercial booms in recent history. The first occurred in late 1941 when the U.S. found itself embroiled in World War II and cut off from tungsten supplies in China, theretofore the primary source of that metal used to toughen gun barrels and armor plate for war. Many of the gold mines in the western U.S. were rich in scheelite, but the latter mineral was not sought during the Gold Rush days. With the use of UV lights, old gold mines and dumps were re-examined by recreational prospectors, and many small- and large-scale scheelite deposits were located. As scheelite in its common granular form generally has no identifying characteristics to set it apart from quartz, feldspar, or carbonate rock (unless it is present in concentrations sufficient that its considerable weight becomes evident), many of the large deposits were worked at night, including the famous Yellow Pine mine in Idaho, with powerful UV lights mounted on bulldozers and other heavy equipment. In 1946, there was a resurgence in UV lights when the newly created Atomic Energy Commission announced bounties for the discovery of new sources of uranium needed to fuel reactors for the production of nuclear energy. By the 1950s, UV lights, along with Geiger counters and later scintillation counters, were again all the rage. These spurts in commercial activity, along with research and development into more efficient phosphors for color TV screens, computer monitors, and optical lasers, have aided the understanding of fluorescence and have resulted in stronger and more durable lamps, filters, and power sources for fluorescent mineral collecting.

Franklin, Sussex County, New Jersey was given the designation of "The Fluorescent Mineral Capital of the World" by the New Jersey State Legislature in 1968, and few would argue this title. The Franklin mine, along with the Sterling Hill mine in neighboring Ogdensburg, is the source of at least 340 minerals, of which at least 82 are fluorescent and at least 10 are uncommonly bright. The five-color fluorescent combinations of calcite (red), willemite (green), hardystonite (purple), esperite (yellow), and clinohedrite (orange) from Franklin are coveted by collectors all over the world. Sadly, the Franklin mine, operational since about 1810, closed in 1954 after having removed over 22 million tons of the world's richest zinc ore (typically ~20% zinc), but the town is still home of the

Franklin Mineral Museum, dedicated in 1965 and boasting a 32-foot-long fluorescent mineral display. Similarly, the Sterling Hill mine closed in 1986, after having yielded about half as much ore as the Franklin mine. Though the deep levels of the Sterling Hill mine have been flooded, the mine reopened to the public on August 4, 1990 as the Sterling Hill Mining Museum, home of an underground tour which includes the impressive "Rainbow Room" and the Landmesser Tunnel, both impressive *in situ* fluorescent mineral displays, lit by SW fluorescent lights from above; several mining dioramas, with authentic mining equipment; and a detailed setup of a working stope, incorporating zinc ore in place. A carefully graded Rock Discovery Center opened in the spring of 1996 at Sterling Hill as a collecting dump for kids. In 1999, the "Thomas S. Warren Museum of Fluorescence" was inaugurated at Sterling Hill, and the Sterling Hill Mining Museum was the recipient of the prestigious Carnegie Mineralogical Award for the same year. Both the Franklin Hill and Sterling Hill museums are open daily from April 1 through November 30, with group visits by appointment in March and December. Two or three public tours, generally taking 1 -2 hours each, run daily at Sterling Hill, with the cost ranging from $7.50 for children under 12, $8.50 for seniors to $10 for other adults. Call ahead for details and current rates: (973) 209-7212. The best time to visit the area is the last Saturday and Sunday of September, when the Franklin-Sterling Gem and Mineral Show, an annual event since 1956, takes place.

Fluorescent minerals come in an immense array of shapes, sizes, species, colors, prices, and localities from all over the world. Collecting them can be a source of endless fascination and delight, but no one can expect to collect them all. Examples of specialty collections within the hobby include:

- Specimens with two or more fluorescent minerals.
- Fluorescent mineral spheres.
- Fluorescent gemstones.
- Fluorescent ore minerals.
- Crystals of fluorescent minerals.
- Phosphorescent minerals.
- Minerals fluorescing more than one color in a single specimen.
- Rare fluorescent minerals, known from only one or a few localities in the world (see above).
- All fluorescent varieties of a particular mineral species, group, or chemical class, e.g., calcite, fluorite; pyroxenes; carbonates.
- All fluorescent minerals containing a certain element (e.g., uranium) in their chemical formulas.
- All fluorescent minerals from a particular locality, e.g., Franklin-Sterling Hill, NJ; Långban, Sweden; Mont St. Hilaire, Quebec, Canada; Tsumeb, Namibia.

The Fluorescent Mineral Society (FMS) was founded in 1971, incorporated in 1993, and currently boasts about 510 members in at least 47 U.S. states and 20 foreign countries. The 1996 Tucson Gem and Mineral Show featured 3,200 square feet—76 display cases— of world-class fluorescent specimens, to help mark the 25th anniversary of the FMS. The FMS has regional vice-presidents in the New England, Northeast, Southeast, South Central, Midwest, Rocky Mountain, Northwest, Desert (Southwest), Northern California,

and Southern California sections of the U.S., as well as in Canada, Europe, and Africa. Its purpose is to share knowledge and experience in the collection, identification, display, and photography of fluorescent minerals, and to encourage research into the ultraviolet spectrum, activators, and the use of ultraviolet lamps and filters. The FMS publishes a newsletter, U.V. Waves (containing a list of other members, offers to trade, notices of FMS activities, and articles of both local and widespread interest), six times yearly and a technical publication, the Journal of the Fluorescent Mineral Society, annually or biennially. The FMS maintains an e-mail list, currently subscribed to by 175 of its members, and has an internet website: http://www.uvminerals.org   The registration fee for new FMS members is $5.00 for U.S. residents, and annual dues are $20.00 for U.S. residents and $23 for those living outside the U.S.. To become a member or to obtain further information about the FMS, check out the above website, contact FMS President Jan Wittenberg P.O. Box 572694, Tarzana, CA 91357-2694, or e-mail Jan Wittenberg at jwitnberg@sbcglobal.net

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