THE EXHIBIT ILLUSTRATING FLUORESCENCE AT THE ACADEMY OF NATURAL SCIENCES OF PHILADELPHIA[1]

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In preparing this exhibit at the Academy of Natural Sciences of Philadelphia, two sources of ultraviolet radiation were considered and tested: the quartz mercury-vapor lamp (of the Hanovia and Cooper-Hewitt types), and carbon arcs with cores of iron.

The quartz mercury-vapor lamps have the great disadvantage in that they must be tilted before they will ignite, and very often do not light with a single tilting. The museum authorities would thus be compelled to install mechanical devices which would tip the lamp, or else permit the tilting to be done by an attendant or the visitor.

While the maximum fluorescent effects are often attained only after an exposure of many minutes, it is also interesting to note the gradual development of these auroral effects. Certain installations permit of continual exposure to the mercury-vapor lamp and in addition use an electric light to obscure the fluorescence when it is desired to observe the minerals under ordinary illumination.

SOURCE OF ULTRAVIOLET RADIATION. It was finally decided that an automatic carbon arc lamp would give the best results in a museum exhibit, and the new Eveready Sunshine Lamp[2] burning four carbons was selected. The carbons used are of the National "C" Therapeutic type which are polymetallic in composition, containing a core of iron, nickel and aluminum, with some silicon, and yielding a maximum amount of ultraviolet radiation.

As the character of the fluorescence depends upon the wave lengths of ultraviolet radiation, obviously different sources of ultraviolet light will cause marked differences in the observed results. The fluorescence of calcites, for example, is apt to be disappointing, when a carbon arc-lamp as described above is used. However, for museum purposes, striking effects can be obtained on most fluorescent minerals, while the automatic feature of a carbon arc makes for a dependable, and practical exhibit.

The weights used to pull the carbons down require adjustment about once an hour if the apparatus is in continuous operation.

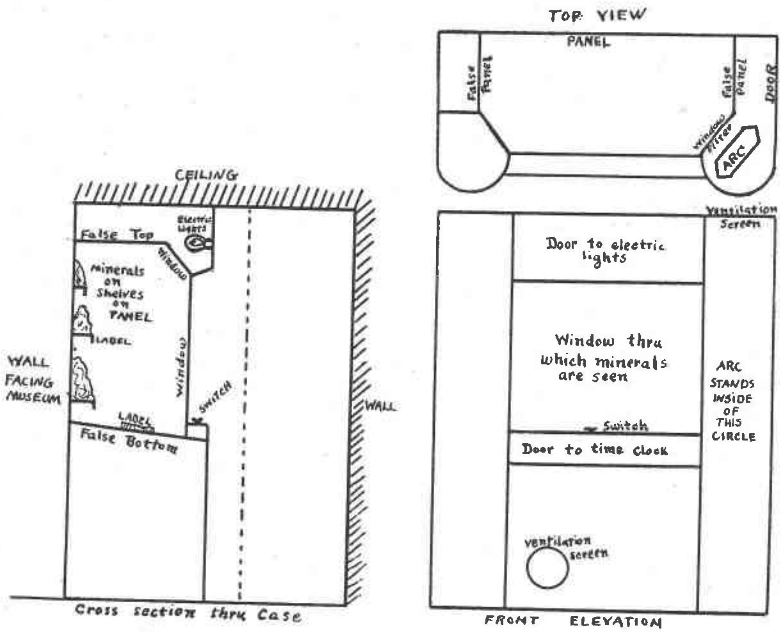

Fig. 1

Color filter. The light from the arc lamp is filtered through a Corning[3] heat resisting red-purple ultra (unpolished) filter. As this glass could not be obtained in sizes larger than 6 1/2 inches square, four 5 inch squares were cemented together to form a window in the case.

Electric lights. In addition to the ultraviolet lamp, three 50 watt electric light bulbs of the "daylight" type are used to illuminate the minerals when the ultraviolet lamp is not in operation.

The switch. The switch consists of a No. 706 single action, single pole Kwixset[4] automatic timing clock, connected with a Dunco[5] double-pole magnetic relay. The carbon arc-lamp and the electric lights are connected directly to the magnetic relay which is operated by the Kwixset time clock.

The action of the switch is as follows: Just the key of the switch projects above the sill in front of the case, and the hole in the sill is just large enough to permit the key to be turned to the one minute point. A visitor coming to the case finds it illuminated by means of the electric light. A label behind the key states: "To operate, turn this switch." Upon doing so, the electric light goes off, and the arc light is turned on, in a single operation. The arc light remains on for one minute, at the end of which it is extinguished automatically, and the electric lights again flash on.

THE CASE. The case (Fig. 1) was built of 2 by 4 inch beams covered with celotex. It contains the carbon arc-lamp in a circular pillar in the right hand front corner of the case; three electric lights hidden in the top; and a panel to hold the minerals which are viewed through a plate glass window.

The panel, 36 by 50 inches, is a single 5 ply wood board, with 18 shelves, each just large enough to hold its particular specimen. The shelves were fastened to the board by means of small angle irons. The panel is fastened to the beams of the back of the case and the case is equipped with a false ceiling, bottom, and false panels on the sides. The entire interior of the case, including the shelves, is covered with black velvet.

The electric lights are placed in the false top, and illuminate the minerals through a concealed window.

The carbon arc is placed in a circular pillar, just large enough to hold the entire apparatus and permit rotation of the top to adjust and replace the carbons. The arc is reached through a door in the side of the case, and the entire apparatus can be lifted through this door. Just in front of the arc is a window, 10 inches square, made of the Corning heat resisting ultra U. V. red purple (unpolished) that serves as a glass filter.

A ventilation screen was placed in the front of the case near the floor, and the space above the electric lights and the carbon arc is open to the ceiling of the hall.

The minerals are viewed through a plate glass window 30 by 36 inches.

Projecting up from the sill in front of the window is the key of the switch. The timing clock, and magnetic relay are concealed in a box below the sill.

PLACING OF THE CASE. The case was built in a corner of the mineral hall, in such a manner that the back of the case faces the hall (Fig. 2). The part facing the mineral hall was left in the natural celotex finish. The walls shown in the figure, ceiling, and front of the case (about the window) were painted a dull black. The two circular pillars at the sides of the case, one of which forms a place for the arc light, serve to shut out the light from the direct view of the visitor. This is an important point, as the intensity of the fluorescence is greatly diminished by the introduction of any extraneous light.

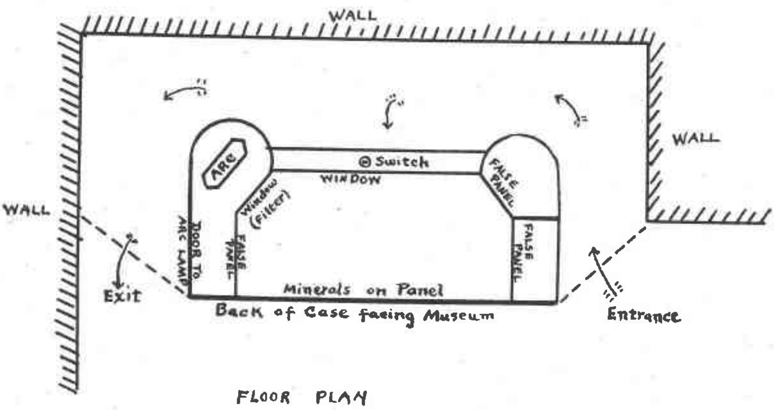

FIG. 2

The position of the ceiling of the case is indicated by the dashed lines in figure 2. No doors or curtains were added, the case alone being used to exclude the light.

THE LABELS. Fastened to the velvet-covered shelf under each mineral is a label, a typical one of which reads:

AUTUNITE
$CaO \cdot 2UO_3 \cdot P_2O_5 \cdot 8H_2O$
LIMOGES, FRANCE
Gift of T. B. Wilson

The labels are of heavy white card board painted over with carbon black. The information is painted on with a fluorescent paint[6] which is a greenish yellow by electric light, and fluoresces with an intense orange glow under the ultraviolet rays.

The general explanatory label is a cleavage slab of microcline, containing the information given below, in two parts: one portion entitled "Reflection," and the other "Fluorescence." The wording of the part called "Reflection" is painted on the microcline in letters of a crimson red water color. Between the lines of the red letters, the data on "Fluorescence" have been painted with a paint which is practically invisible in electric light, but which fluoresces with a greenish glow. The part called "Reflection" is, therefore, visible only under the electric light, and the lines entitled "Fluorescence" appear only under the ultraviolet rays.

A more complete explanatory label appears at the entrance to the exhibit.

REFLECTION

These minerals are now seen under
an electric light which emits light
of all colors. The colors shown by
the minerals are, therefore, those of
the color of light they reflect, as
the other colors are absorbed.
Now turn off the electric light

FLUORESCENCE

Ultraviolet rays are now falling
on these specimens. These few
minerals have the property of absorbing
these rays and stepping them up to
the wavelengths of visible light.
The new light, created within the
minerals from the invisible ultra-
violets rays, is emitted as a cold glow.

THE MINERALS. Eighteen mineral specimens were selected for the exhibit because of the intensity of their fluorescence and the variety of color shown. These were selected after examining about 15,000 specimens, at night time. It was possible to do this as the arc light is portable, and could be rolled from case to case.

The minerals are listed in the table below, which gives also their fluorescent color. Most of these minerals are well known for their fluorescence, and only the wernerite and sodalite need further comment.

FLUORESCENCE OF WERNERITE FROM CANADA. The wernerite was labeled as coming from Grenville, Canada. It was found to be the *most fluorescent* of all of the minerals examined, exhibiting an intense lemon yellow color.

The mineral in daylight is barium yellow (Ridgway) in color. It was found to be optically negative, with the indices $\epsilon=1.555$, and $\omega=1.590$. It thus corresponds to:

Ma (Marialite)	$2NaCl \cdot 3Na_2O \cdot 3Al_2O_3 \cdot 18SiO_2$	70%
Me (Meionite)	$4CaO \cdot 3Al_2O_3 \cdot 6SiO_2$	30%

Associated with it is a colorless diopside, which appears black under the ultraviolet rays.

FLUORESCENCE OF SODALITE FROM GREENLAND.[7] The sodalite is in large cleavage masses collected by the writer in 1923 at Tugtup Agtakorfia, Tunugdliarfik, Greenland, in the cliff formed by the largest of the naujaite masses in the lujavrite. It is practically colorless, excepting where it includes needles of aegirite. It fluoresces with a cadmium (orange) yellow color. Some inclusions of albite show a purple tint.

TABLE 1. THE MINERALS EXHIBITED

MINERAL	LOCALITY	COLOR	FLUORESCENT COLOR
Fluorite	Weardale, England	Violet	Bluish violet
"	" "	"	" "
"	Alston, England	"	" "
Hyalite	Bedford, New York	Colorless	Green
Autunite	Philadelphia	Yellow	Green
"	Limoges, France	"	"
Willemite	Franklin, N. J.	Pale green	Neva green
"	" "	" "	" "
Willemite and Calcite	Franklin, N. J.	Pale green White	Neva green Scarlet
Anglesite	Phoenixville	Colorless	Pale greenish
Brucite	Lancaster Co., Pa.	White	Pale bluish white
Wernerite	Grenville, Canada	Barium-yellow	Lemon yellow
Sodalite	Greenland	Colorless	Cadmium yellow
Aragonite	Girgenti, Sicily	White	Rose pink
Ruby corundum	Buck Creek, N. C.	Red	Scarlet

In addition, two fossils in the lithographic limestone from Solenhofen,—a crustacean and a fish,—are exhibited.

The minerals have been arranged on the panel so as to present a more or less harmonious distribution of the colors and intensities.

FOOTNOTES AND REFERENCES

[1] An account of the exhibit illustrating fluorescence in the British Museum (Natural History) by Dr. L. J. Spencer appeared in this magazine, **14**, 33–37, 1929; in the *Natural History Magazine*, **1**, 291–298, 1928; with a reference in *Science* of December 7, **1928**, p. 560 (taken from the *London Times*).

References to exhibits illustrating fluorescence in the Museums of the Peaceful Arts in New York City, and in the Buffalo Society of Natural Sciences appeared in *Science*, **69**, page 167, 1929.

[2] National Carbon Co., Inc., Cleveland, Ohio. This is a therapeutic lamp now on the market for $137.50. The C carbons cost about 25c apiece. About one carbon a day is consumed.

[3] Corning Glass Works, Corning, N. Y. The filters are described in Dr. Gage's booklet "Glass Color Filters" distributed free by the company. A particularly useful glass manufactured by this company is a faintly tinted didymium glass which cuts out the two sodium lines of the spectrum, and is superior to cobalt glass for examining flame colors.

[4] H. C. Thompson Clock Co., 2032 Grand Central Terminal, New York City; $15.00.

[5] Struthers Dunn, Inc., 1130 Race Street, Philadelphia; Type 829 with 4 blow-out coils for direct current ($17.00).

[6] Purchased from Frank Hartman (Radium Products Co.), 1920 Walnut Street, Philadelphia, Pa.

[7] Fluorescence in sodalite was described by T. Liebisch; *Sitzungsber. Preuss. Akad. Wiss., Berlin*, **1912**, 229–240.