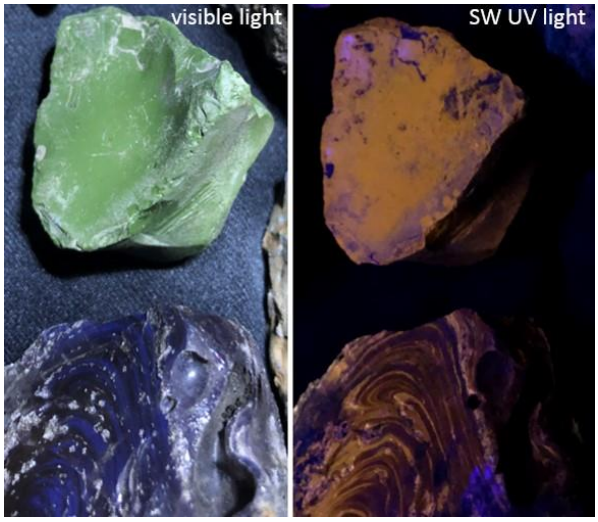
Fluorescence in Blast Furnace Slag

Slag, a waste product from smelting iron ore into pig iron in a blast furnace, is commonly found around Pine Grove Furnace (in operation 1770s-1895). Some specimens glow with various colors when an ultraviolet (UV) light shines on them. This effect is called *fluorescence*.



As explained below, the type of lamp matters. Typical inexpensive UV lamps shine at long wavelengths around 365 nanometers (called "UVA") and often do not produce interesting results when examining minerals. The most dramatic colors are seen with a more expensive shortwave light bulb that shines at a wavelength of 254 nanometers ("UVC"). UV lamps often produce light at more than one wavelength: they may show a gentle purple glow directly visible with your eyes, but the fluorescent effect is due to wavelengths of light you cannot see. What you can't see can hurt you. **Never look directly at a UV lamp! It can quickly damage your eyes. It can also burn your skin. UV lamps are not toys and should be used only with responsible adult supervision.**

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The following is excerpted from *Fluorescent Minerals: Learn about the minerals and rocks that "glow" under ultraviolet light* by Hobart M. King, PhD, RPG at *https://geology.com/articles/fluorescent-minerals*

Some minerals have an interesting physical property known as "fluorescence." These minerals have the ability to temporarily absorb a small amount of light and an instant later release a small amount of light of a different wavelength. This change in wavelength causes a temporary color change...

Most minerals do not have a noticeable fluorescence. Only about 15% of minerals have a fluorescence that is visible to people, and some specimens of those minerals will not fluoresce. Fluorescence usually occurs when specific impurities known as "activators" are present within the mineral. These activators are typically cations of metals such as: tungsten, molybdenum, lead, boron, titanium, manganese, uranium, and chromium. Rare earth elements... are also known to contribute to the fluorescence phenomenon. Fluorescence can also be caused by crystal structural defects or organic impurities.

In addition to "activator" impurities, some impurities have a dampening effect on fluorescence. If iron or copper are present as impurities, they can reduce or eliminate fluorescence. Furthermore, if the activator mineral is present in large amounts, that can reduce the fluorescence effect.

Ultraviolet Wavelength Range			
	Wavelength	Abbreviations	
Shortwave	100-280nm	SW	UVC
Midwave	280-315nm	MW	UVB
Longwave	315-400nm	LW	UVA

Most minerals fluoresce a single color. Other minerals have multiple colors of fluorescence... Many minerals fluoresce one color under shortwave UV light and another color under longwave UV light.

The lamps used to locate and study fluorescent minerals are very different from the ultraviolet lamps (called "black lights") sold in novelty stores [sometimes used to find pet urine stains]. The novelty store lamps are not suitable for mineral studies for two reasons: 1) they emit longwave ultraviolet light (most fluorescent minerals respond to shortwave ultraviolet); and, 2) they emit a significant amount of visible light which interferes with accurate observation.

...Small UV lamps with just a few watts of power are safe for short periods of use. The user should not look into the lamp, shine the lamp directly onto the skin, or shine the lamp towards the face of a person or pet...

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A technical paper examined slag from modern steel furnaces, similar but quite not the same as slag from blast furnaces. Researchers at the "2013 Slag Valorization Symposium" in Belgium reported:

> Orange colour [in one type of steel slag] under short wave UV light... may be assigned to **cuspidine** [a calcium silicate mineral containing fluorine]... [In a different type of steel slag] orange colour under UV lamps... can be assigned of **beta-dicalcium silicate** (ß-Ca_2SiO_4), blue colour to **fluorite** CaF_2 and purple colour to **chromium spinels** $MgCrO_4$. However, it remains an uncertainty because fluorite can appear in several colours under UV lamps according to its impurities.

Colors in slag under UV light may also be due to **manganese** and **sulfur**. Some of the iron ore used at Pine Grove Furnace was relatively high in manganese, resulting in sky-blue slag. Sulfur, which can create brittle finished iron, was present at only low amounts in local iron ore but its level was not zero. Sulfur can also be introduced via anthracite or coke (imported coal was sometimes used as fuel instead of local charcoal at Pine Grove in the final two decades of operation). Fortunately sulfur tends to combine with manganese and ends up in the slag, removing most of it from the finished metal products.

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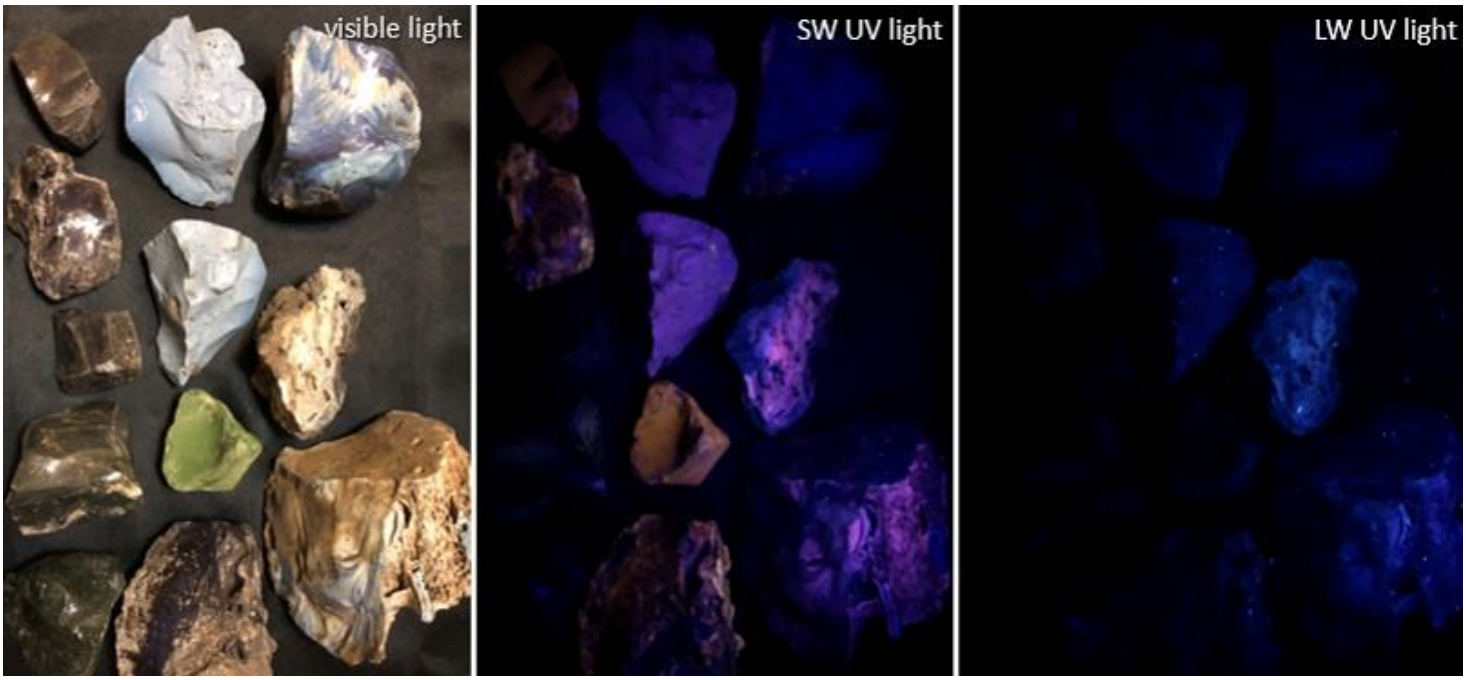
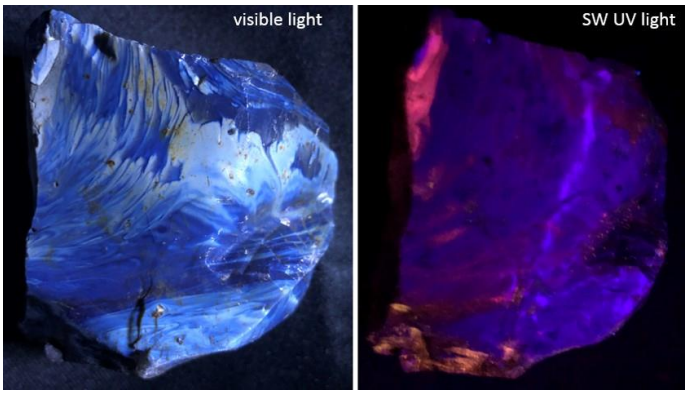
Here is slag from Pine Grove Furnace in visible light and in shortwave and longwave UV light:





Photos in this essay were taken with a high quality UV lamp from *https://www.uvtools.com/products/m101ho-11-watt-shortwave-longwave-ultraviolet-lamp-kit-click-here*. The longwave picture above was not via a cheap "blacklight."

Various specimens of slag from Pine Grove Furnace shine orange, purple or red under shortwave UV light (the images here do not adequately convey the colors). Some slag from other historic furnace sites reportedly also shines orange. Longwave UV light reveals a few whitish specks but not much else. Some slag doesn't shine at all. Why? We don't know! Do you? Please share your knowledge.

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FRIENDS OF Pine Grove Furnace STATE PARK
Pennsylvania Parks & Forests Foundation