The Color of Iron

Gold is for the mistress – silver for the maid –
copper for the craftsman, cunning at his trade.
"Good!" said the Baron, sitting in his hall,
"But Iron – Cold Iron – is master of them all."

–Rudyard Kipling

Iron is one of the most abundant elements in the earth. It plays a significant role not only in geology, biology and medicine, but also in art. Today the art and science of iron are separated by a cultural divide, but this was not always true. Historically, artisans have manipulated the physical and chemical properties of iron in order to achieve a range of colors. From the ancient technique of heating and grinding iron oxides to produce shades of yellow, orange, red, and black, to the elaborate eighteenth–century process of making Prussian blue from animal blood and potash, the science and art of iron were united by a common purpose: making color.

As a scientist, I came across the magnificent colors of iron in the summer of 1999 while I was working in the radiogenic isotope lab in the UW–Madison Department of Geology and Geophysics. I was part of a team using a newly developed technique to answer basic questions about how iron behaves in the earth, the oceans, and in living things. In a series of experiments, I dissolved iron compounds and minerals in water and acids and watched what happened over time.

Iron compounds and solutions are colorful. Within a week my workbench was cluttered with dozens of vials and beakers filled with multicolored powders, sludges and solutions. I loved the colors, especially in the afternoon when sunlight hit the workbench and made them glow—many iron compounds are sensitive to light and react in unexpected ways when illuminated. And I loved the way the solutions changed over time.

I did not experience these things as aesthetic pleasures separate from my fascination with the science of iron, but as part of that fascination. Many of the colorful materials that I was using and creating similarly have fascinated artists for centuries.

This exhibition is my attempt to recover and share this delight, through the work of four artists who long have been inspired by the colors that iron can achieve in the favored medium of each: Saundra McPherson in ochre and other natural iron pigments used in painting; Michael Ware in the Prussian blue of cyanotype photography; Scott Shapiro in iron-tinted glass; and John Britt in iron-pigmented ceramic glazes. The fifth component of this exhibition, the Alchemist's Workbench, serves to unite this art with scientific aspects of the properties of iron. The displayed works were created especially for this exhibition, in celebration of The Color of Iron.

--Joe Skulan, UW Geology Museum

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The Alchemist's Workbench

Alchemists, whose work inspired both modern science and art, delighted in the manipulation of substance and color. Iron, as one of the seven metals recognized by them, can be made to take on different appearances. In fact, every color on this workbench is produced with iron. On it, one can see substances used by the artists in this exhibition, along with others that are unsuitable as pigments. Many of these materials react with light and with the oxygen and carbon dioxide in the atmosphere. Thus, the appearance of the materials changes from day to day. As they change, they produce beautiful effects that are seldom seen outside of the laboratory.

Some Basic Principles:

Hue

The most basic determinate of the color that iron will produce is its *oxidation state.* Iron atoms in chemical compounds usually exist in one of two forms: atoms with an electrical charge of +3 (Fe^{+++} or ferr*ic* iron) and atoms with a charge of +2 (Fe^{++} or ferr*ous* iron). Although there are exceptions, as a rule, ferric iron produces yellows, oranges and reds while ferrous iron produces blues and violets. Green usually indicates a mix of ferrous and ferric iron.

Intensity

Bright colors, such as that of Prussian blue and the colors of iron-pigmented gems, are produced at the molecular level by the interaction of light with the chemical bonds between iron and other atoms.

Earth tones are produced by the interaction of light with the surfaces of crystals. Changing the size of crystals changes their color, which is why grinding often is an important part of making iron-based pigments.

Transparency

Some of the materials on display are transparent: light shines through them with no trace of cloudiness. These are examples of true solutions – iron atoms are not bound to each other but are dispersed between the molecules of the substance in which they are dissolved.

Other materials are cloudy or lumpy. This appearance comes from tiny particles of iron oxides that are forming from iron in solution.

Most of the glass vessels on the workbench were created for this exhibit by artists Scott Shapiro and Tracy Drier. Some of these vessels are replicas of real alchemical glassware, while others were inspired by the alchemical spirit of the exhibition.

Paintings in Iron
By Saundra McPherson

San Francisco-based Artist Saundra McPherson applies her long-standing interest in geology to create these paintings, which display the range of colors that iron can impart to pigments. Most of the pigments in these paintings come from natural, iron-containing minerals. These same minerals give spectacular color to desert landscapes.

McPherson's paintings incorporate the most ancient of all iron pigments: the red, yellow and orange iron oxides that Paleolithic artists used 15,000 years ago to create murals in the caves of Lascaux, France.

Iron-Based Glazes
By John Britt

John Britt uses his knowledge of iron chemistry and careful manipulation of oxygen level, temperature and firing time to produce the range of colors and effects displayed by these vessels. Reds, yellows and blacks are produced by the same iron oxides that create these colors in paintings; blues and olive green are created by the dissolution of iron in transparent glaze – the same process that gives color to glass. The sparkle and iridescence visible on many of the pieces is caused by tiny crystals or films of iron metal.

Cyanotypes
By Dr. Michael Ware

Cyanotypes are photographs rendered in Prussian blue (iron ferrous cyanide or iron (III) hexacyanoferrate (II)). Cyanotypes are made on paper coated with a water-based sensitizer, or a mixture of iron compounds that react to form tiny crystals of Prussian blue when exposed to light. These crystals form on and inside of the paper fibers, and do not wash away when the residual sensitizer is removed with water. Sunprints and the eponymous blueprint are made by the same process.

First made in the early eighteenth century, Prussian blue is a late addition to the palette of iron-based pigments. The molecular structure of Prussian blue contains many boxlike cavities that can trap atoms of other metals. Artists can adjust the color and tone of cyanotypes by filling these cavities with metals such as lead, thallium, gallate, phosphate or nickel, as shown in these photographs.

Iron-Pigmented Glass
By Scott Shapiro

In these works, Scott Shapiro uses reflected and transmitted light to display the range of colors iron can impart to glass. Iron-pigmented glass was used for many years to produce Coca-Cola bottles. "Coke bottle green"– the same green you see if you look at a window pane on edge – results from a small amount of iron dissolved in the glass. Under most conditions, more iron produces a darker green, and even the black of the natural volcanic glass obsidian. If heated in the presence of large amounts of oxygen, glass containing iron will turn yellow; in the absence of oxygen, such glass will be blue. Iron sulfide (the mineral pyrite, or "fool's gold") gives glass a color ranging from amber to beer-bottle brown, depending on its concentration.