

Minerals and Paint:
The use of minerals as pigments



If applied to a surface harder than itself, a mineral can be used as an artistic medium.

For example, graphite, which has a hardness of 1, leaves a black mark on paper.

...but few minerals are this soft !

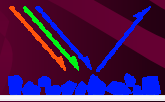


Since prehistoric times, minerals have been used widely for the manufacture of pigments.

As mentioned previously in the course, many minerals have distinctive colours that result from their chemical compositions.

In this lecture, we will examine the types of minerals that have been used as pigments.

The colour of pigments (of everything really) relates to the part of the visible light spectrum which is reflected from their surfaces (other frequencies of visible light are absorbed).



Most minerals must be crushed, powdered, and mixed with other substances to produce a workable pigment. The first paints were probably mixtures of pigment, clays, animal fats and "filler" minerals such as gypsum or calcite.



Earliest paintings

The prehistoric artists (Cro-Magnons) who produced the earliest known paintings in the caves of Lascaux, France (15,000 B.C.), used charcoal as well as red and yellow pigments called red ochre and yellow ochre. They also painted their own bodies with these pigments.



Ancient Egyptians: Paint

The Egyptians apparently used pigments for paint as well.

Among the various artifacts found in Tutankhamun's tomb (meant to accompany King Tut in his journey to the afterlife), was found a small paint box.

The paint box was found to contain powders of:



Gypsum Orpiment Hematite Malachite
(Arsenic sulphide)

Two types of ochre

Red ochre is made from the mineral hematite (iron oxide)



Hematite: Fe₂O₃

Yellow ochre is made from the mineral limonite (iron oxyhydroxide)



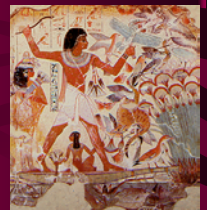
Limonite: FeO(OH).H₂O

Tomb Paintings

Egyptian artists covered limestone walls of tombs with a fine layer of plaster, onto which they painted various scenes.

Painters used primarily black, red, yellow, brown, blue, and green pigments. They mixed their colors in a binder to make them stick to the dry plaster.

By applying the colors thinly or thickly, or by mixing them with black and white pigments, the Egyptian artist achieved a great range of colors and values.



Ancient Egyptians: Makeup

The Egyptian also used minerals in their cosmetics.

Red ochre was applied to the lips

Eye-makeup or "Kohl" contained various powdered minerals.

- Stibnite (black)
- Malachite (green)
- Azurite (dark blue)
- Turquoise (turquoise)
- Lapis Lazuli (deep blue)

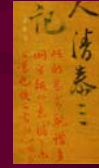


Vermilion, made from the mineral cinnabar was used to paint the face of Jupiter's statue in Rome during significant events.

It was, and still is, used for inks in Chinese calligraphy.



Cinnabar: HgS



Calligraphy in cinnabar ink

Natron and the Quest for Eternity

Natron, a hydrated sodium carbonate mineral was used extensively by the ancient Egyptians in a variety of roles, most notably in embalming and mummification, various forms of cleaning (including personal hygiene) and pest control.

Though not a pigment or a cosmetic as such, it was believed to be very important in the maintenance of beauty of both the living and the dead.

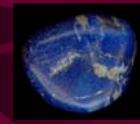
Natron has two important properties which promote preservation of organic materials by inhibiting bacterial decay:

- 1) Natron (like halite) is a very effective desiccant (removal of water impedes bacterial and other forms of decay).
- 2) Natron, in the presence of water or moisture, produces a basic (high pH) solution hostile to bacteria.

Natron was also an ingredient (with lime and copper) used in the production of "Egyptian Blue", the world's first synthetic pigment (used up to Roman times).

Medieval paintings of the Virgin Mary feature a vivid blue colour in her cloak.

Lapis lazuli from Afghanistan was the source of this blue pigment used by medieval artists for paintings of the Virgin Mary.



Lapis lazuli
Lazurite: $\text{Na}_8(\text{SO}_4)(\text{AlSiO}_4)_6$



Medieval painting

The Russians used the vivid green mineral diopside (collected in Siberia) in their religious icons.

Diopside: $\text{CuSiO}_2(\text{OH})_2$



Throughout history (and before!) people have used much the same minerals again and again for colours, both in paint and in cosmetics.

Hematite is still used in some modern lipsticks! Mica is also added for a "glitter" effect.



Minerals continued to be used in cosmetics well into the 16th century. Elizabeth the First of England used powdered cerussite (lead carbonate), which has a high refractive index (very bright), but is also very poisonous! Cerussite: PbCO_3 "cerussa" (Latin) = "white lead".



Interesting fact: due to skin damage from the lead (leading to a shriveled, grey appearance), Liz had to wear more and more make-up as she grew older to maintain a pale complexion!

Modern Paints

The principle of modern paint making is essentially the same as that used in ancient times.

Paint consists of two things: pigment and binder.

Pigment is what gives color to paint (generally sold as a fine powder).

Binder is what holds the pigment grains together (allowing it to be spread). It also is the medium which adheres the pigment to a surface.

The pigment particles are insoluble and merely form a suspension in the binder.

Natural Inorganic Pigments in Modern Paint

Natural pigments from minerals are present in some paints used by modern artists (although many have been replaced by synthetic pigments).

Common natural inorganic pigments include:



Vermilion
(cinnabar)



Terre verte
(Glauconite clay)



Ultramarine
(Lazurite)

Note also that white or neutral-coloured paint primers also contain powdered minerals (gesso is basically suspension of gypsum and a binder).



Artificial Inorganic Pigments

Artificial inorganic pigments, are pigments that are produced rather than found. The ultimate sources of metals in these pigments are minerals (the raw materials still need to be mined or otherwise obtained from natural sources).

This allows for better "quality control" of pigments.

Pigments produced in this way include:



Titanium white
(titanium oxide)



Cobalt blue
(cobalt oxide)



Cadmium red
(cadmium seleno-sulphide)

Organic pigments

Other pigments are made from carbon-based (non-mineral) substances. Organic pigments include both natural and manufactured synthetic forms.

Examples of natural organic pigments:



Indian Yellow
(urine of cows fed mango leaves; Mg salts)



Indigo
(from leaves of Indigo plant)



Bone black
(charred bone; C, Ca phosphates and carbonates)

Examples of synthetic organic pigments:



Prussian blue
(iron hexacyanoferrate)



Naphthol red
(naphthol)



Dioxazine Purple
(carbazole dioxazine)

Put these things together and you get paint !



Binders

A variety of materials are used as binders. These include:
Beeswax (in encaustic paints)
Casein ("kay seen" a milk protein) mixed with borax
Egg yolk (in tempera paint)
Plaster (pigment added to plaster surface in fresco paintings)
Gum arabic (in watercolour paint; dissolves in water)
Hide glue (in distemper paints)
Linseed oil (in oil paints)
Acrylic emulsion (in acrylic paints)

Casein and egg yolk also function as emulsifiers that keep the pigment particles in suspension

The terminology for various categories of paints (as above) is usually a reference to the binding medium.

Add the Artist, And You Get A Painting

So next time you attempt to paint a landscape, keep in mind that you might well be using materials that came from the Earth Itself !



Lawren Harris (one of the "Group of Seven" famous Canadian landscape painters)
"Mountain Forms" 1928

