THE DIRT ON COLORS

A Mineral Pigment Primer

By Steven Edholm & Tamara Wilder c 1998

Since the era of the Neanderthals, "people" have been brightening their world with pigments from animal, mineral, and vegetable sources. These same sources have continued to be used for a very long time, and are still in use today (that is to say even outside of the likes of S.P.T. readers and surviving basic technology peoples). Through time, a rich heritage of painting and drawing materials developed. The artist was, of necessity, the maker and mixer of his or her own paints, combining oils, resins, glues, mordants, catalysts, and pigments to create a substance which would flow or adhere properly, be and remain durable, have an appropriate finish (glazed, flat, etc.), and, of course, be of and remain the proper color. The art of creating paints is a vast body of knowledge comprised of layer upon layer of experiences passed down and built upon by manifold generations of color users, a great project for the technological sleuth so inclined.


Tamara Wilder

Natural pigment paint applied with a primitive "airbrush" (see BPT# 10).

The most common and widespread sources of color for paints are minerals, i.e. colored earth; therefore, this article will focus on some of the basic concepts and techniques by which a person may utilize mineral colors, including some basic binding media.

We feel it safe to say (knock on oak) that mineral pigments are never used as dyes, but rather as solid color, dust if you will, applied to a surface and usually held there within the matrix of a binder. A dye, on the other hand, affixes by physically or chemically bonding to a material. Dyes can, however, sometimes be used as a pigment by concentrating them and/or drying them into a powder. In this form, they also need a binder and act as a surface color.

The pigment in a dye often requires a mordant to affix it to the material being dyed and several minerals which give earth pigments also serve this purpose-namely alum, chromium, copper, tin, and iron. Unfortunately, not just any rock or earth containing one of these minerals will work as a mordant. The mineral must be of the appropriate chemical composition in regards to its combination with other elements. This discussion is somewhat of a digression as this article doesn't deal with dyes and mordants but in the world of earth pigments, it is this same concept of minerals entering into combination with other elements which provides us with differing colors from the same mineral base, i.e. iron oxides occur in many different forms/colors such as (magnetite-black, ***ferro ferric oxide,*** hematite-red, ***ferric oxide;*** limonite-yellow, ***hydrated ferric oxide)***

Mineral colors are common enough, the various colored rocks and earths providing more or less brilliant colors for preparation and use by the would be painter. Unfortunately, less brilliant colors are more common and generally the rule, while brilliant rich colors are relatively rare and exceptional. Yellows, oranges, reds, browns and whites are common. Blues, greens, and blacks are harder to find. Nowadays, the modern forager has access to the car and can roam from roadcut to roadcut, the source of many layers of brightly colored earth which would otherwise be hidden from view. Always remember...Watch the roadcuts as you drive.

Identifying Pigments

Mineral pigment colors are made of naturally occurring colored earth. The color is caused by minerals or combinations of minerals and elements, many of which can be dangerous and toxic. Knowing just which materials are causing the color can help you to know whether they are safe or whether they could be dangerous to handle and use. This can be a difficult task, but with some guidelines, you can feel like you have at least a vague idea of what you're gathering.

The four biggies to avoid are ***mercury, lead, arsenic, and antimony.*** All four cause brilliant colors and often make very high quality pigment and paint. For these reasons, they are the base ingredients of many of the manufactured pigments used in painting. Unfortunately, all of these materials are highly toxic. They also accumulate in fat, which makes them extremely difficult to get rid of once you have absorbed them.

Mercury and lead have been commonly used by people worldwide for red and black - even as a body paint. Nowadays, we understand the detrimental effects of these materials and can avoid them. Mercury red ***(cinnabar-vermi//ion)*** is an extremely brilliant red which eventually turns black upon exposure to light. It is incredibly toxic. One of the places it occurs naturally is in central California; from there, it was traded all across the west.

Lead black ***(ga/ena)*** is a naturally occurring lead ore which was used by many tribes and is highly toxic. It makes a white when exposed to acid ***(lead carbonate)*** White lead is one of the most toxic of all pigments. Red lead ***(Litharge, lead monoxide)*** was used by some northern tribes and is also extremely toxic.

Arsenic and antimony are often contained within other materials, especially those with gray metallic sheens. Sometimes they occur in graphite, but usually not in iron. Arsenic can usually be detected by its garlic smell - either plain or especially when heated. Antimony generally acts like arsenic but doesn't smell.

The second group contains copper, chromium, zinc, manganese, cobalt, and barium. These materials can cause cumulative effects when you are overexposed to them. Fortunately, they are not easily absorbed by the body in normal use. Caution should be taken with prolonged contact with the skin and they should definitely not be ingested, inhaled, or heated. **Cadmium,** especially, becomes extremely toxic when burned. In general, these materials can be safely utilized, but caution should always be taken and they shouldn't be used on eating utensils or where they will come into prolonged contact with your body.

The third group contains iron, calcium, carbon and magnesium. These are safe and can be utilized without worry. The only cautions are that **copper** can sometimes be present in **iron** and that **lead, arsenic, and antimony** can sometimes can be present in **graphite (a form of** carbon). Iron, calcium, and carbon are extremely common and widely occurring.

Ochres (iron oxides) are iron-based pigments which commonly occur in yellow, orange, red, brown, and black. They sometimes occur in blue and green. Iron based pigments are probably the most common and are fairly easy to find and identify. They are also among the safest. Iron oxides sometimes contain silicic acid (mineral salts) which apparently enhance the color and seem to have been sought after.

Here are some specifics that help identifv pigments

- *iron yellow ochres change to oranges and/or reds when burned.*
- *all forms of copper are supposed to turn ammonia blue.*
- *arsenic smells like garlic.*
- *mercury can turn black with prolonged exposure to light.*
- *lead turns white when exposed to an acid.*

So...how do you decide if a pigment is safe or not?

First, use common sense. Think about where you are. If you have heard about old mercury mines in the area, then be especially cautious. If you know that copper is mined in your vicinity, keep in mind that there could be copper with the iron. Also use the identifying characteristics given about individual minerals. In addition, remember that the more brilliant and mind-blowing the color, the greater the chance it contains dangerous substances.

Secondly, you can try to test your materials. Old time mineralogists often used a technique called the "bead" test to determine the composition of rocks. This test consists of heating the mineral; the resulting color-both when hot as well as cold-identifies the composition. A description of this test, along with keys to what the colors indicate, can often be found in old mineralogy books, such as ***Dana's Mineralogy,*** from the 1930's to 1940's. You could also try to get your samples tested by somebody else.

Finally, if you are especially cautious and/or are working with children, you can always purchase these natural pigments already identified for you. Many art supply stores carry earth pigments in powdered form or you can mail order them from the catalogues listed at the end of this article. Remember that the dangerous ones are sold too, so you still have to know what you're looking for.

Selecting Pigments

Once color is found, you have to decide whether that color is intrinsic to the stone or merely the result of light refracting through its structure. You may get excited over some gorgeous blue rock only to find that there is no color when it is crushed. An easy way to test color in the field is by **streaking. No,** not running around naked (though you may if you wish to since it won't affect the test, unless you get arrested), but by rubbing the mineral in question against a harder stone to see what color it leaves behind. The geologically inclined carry a white unglazed tile for this purpose, but a suitable stone can usually be found on site. If the streak is white, then the color is not intrinsic to the stone and cannot be used as pigment.

The streak test passed, the next factors to consider are the **hardness and grindability of the stone and** the **dispersion qualities** of the color when ground. The very nicely colored two twenty-nine blue (named for mile marker 229 highway 20 Oregon) is so hard that it is very difficult to grind. Ground in a mortar, the product of much effort is meager at best; after settling, only a light coating of dust is usually left in the settling jar. Furthermore, even the finely ground powder doesn't seem to mix very well with binders, having a tendency to separate in the binding media.

Two twenty-nine blue is a perfect example of a pigment with a lot of problems (extremely hard with poor dispersion), but which also has a wonderful color that is relatively difficult to find. For these reasons, it has lead to some creative processes for its reduction. Friend/artist/ craftsman Steve Allely uses a power grinder and collects the very fine dust for use. Pegg Mathewson puts two twenty-nine in a rock tumbler and

(more)

YELLOWS

Yellow ochre, Iimonite: (hydrated ferric oxide) Iron based pigment. Extremely common. Ranges yellow to orangish.

Litharge, yellow lead: (lead monoxide) Lead based pigment used by some Native American groups. HIGHLY TOXIC.

Orpiment: (arsenic *disulphide)* Arsenic based pigment used in the Old World for paint, but its use was discontinued due to its highly toxic nature. Has translucent luster and streaks pale yellow. When heated smells like garlic. Occurs with realgar in US at Mercur UT, Manhattan NV; Norris Geyser Basin in Yellowstone Nat'1 Park. EXTREMELY TOXIC.

REDS

Red ochre, hematite: (ferric *oxide)* Iron based pigment. Yellow ochre is converted to red ochre by heat-either naturally or intentionally. Apparently, the more intense the heat, the deeper the red. T--he intensity of the red is limited by the quality of the ochre in the first place. Often called burnt ochre.

Realgar: (arsenic *sulphide)* Arsenic based pigment used in the Old World for paint, but its use was discontinued due to its highly toxic nature. Has translucent to transparent resinous luster and streaks orange to red. When heated smells like garlic, Occurs with orpiment in the US at Mercur UT, Manhattan, NV, Norris Geyser Basin in YellowstoneNat'1 Park. EXTREMELY TOXIC.

Cinnabar/vermillion: *(mercury sulphate)* Mercury based brilliant red pigment which is supposed to turn black after prolonged exposure to light. Can also be brownish when impure. Was widely used and traded for by people worldwide. Streaks scarlet. In US, large deposits are found in California (San Benito Co., Napa Co.; Santa Clara Co.), Nevada, Utah, Oregon, Arkansas, Idaho, and Texas. EXTREMELY TOXIC.

Litharge/Minium, red lead: (lead *monoxide)* Lead based pigment used by some Native American groups. HIGHLY TOXIC.

BROWNS

Siennas and umbers, limonite: *(hydrated* *ferric oxides)* Iron based pigments. Siennas indicate yellowish brown while umbers indicate darker reddish browns Often occur in softish chalky lumps in creek beds, etc.

Manganese: *(manganese* *oxide)* Manganese based black/brown stone. OK but remember cautions about manganese-mentioned above.

Asphaltum: *(bitumen)* Mineral tar composed of hydrocarbons. Possibly carcinogenic in similar manner to petroleum.

BLUES

Blue earth: (iron oxide compound) Iron based pigment. Apparently relatively rare.

Blue **coppers, Azurite:** *(copper carbonate)* Copper salts which are fairly common and possess nice azure blue color, OK but remember warmngs about copper mentioned above.

UItramarine: (lapis lazoli) Old time pigment from a ground up semi-precious stone, *Lapis* has always been rare and expensive.

GREENS

Green earth: (iron *oxide compound)* Iron based pigment. Apparently relatively rare.

Green coppers, Malachite: (*copper carbonate)* Copper salts which are fairly common and possess nice bright green color. OK but remember warnings about copper mentioned above. Also naturally forms on copper from combination with carbon dioxide in the air.

Verdigris: (copper acetate) Produced by combination of copper and acid (vinegar). POISONOUS.

BLACKS

Magnetite/Lodestone: *(ferroferric oxide)* Iron based blackish metallic looking stone. Slightly magnetic and streaks black to reddish brown.

Manganese: *(manganese oxide)* Manganese based black/brown stone. OK, but remember warnings about manganese.

Graphite: *(carbon)* Carbon based fairly common silver-black stone. Can sometimes contain lead, arsenic and antimony. Pencils are made of graphite mixed with clay.

GaIena: (lead sulphide) Silver to black lead ore with metallic luster and lead-gray streak. Relatively soft Very common. Used by some Native American groups for black paint. HIGHLY TOXIC.

Bone black, Animal charcoal: *(carbonized bone)* Made by incompletely charring bones.

Vine black, Charcoal: *(carbonized wood)* Made by incompletely charring wood

Lamp black, Soot: Made by gathering the incompletely burned carbon particles in smoke. Best made by interrupting the flame of burning oil, fat, or pitch.

WHITES

ChaIk: *(calcium carbonate)* Basic white chalk.

Gypsum: *(hydrated calcium sulphate)*

Clay, Kaolin. Feldspar: *(aluminum silicate)* White forms can be used as white pigment.

Talcum: *(hydrated magnesium)*

Barite: *(barium sulphate)* Common

Lead white: *(lead carbonate)* Lead based. Result of reaction between lead and an acid. EXTREMELY TOXIC.

Alum white: *(potassium aluminum sulphate)* Mixed with honey.

Diatomaceous earth: *(silica)* Sedimentary deposit formed of the fossils of diatoms - microscopic algae composed largely of silica.

As you can see, there are numerous materials which produce desirable pigments. If you really start getting into gathering your own, we suggest getting some mineralogy books and familiarizing yourself even more with their different identifying characteristics especially for the dangerous ones.

just lets it bounce around on itself. You might be saying to yourself, "That's cheating.", but cheating is only relative to rules (if any) set down by the individual. If this is taken to be the case then one has ones own rules and guidelines and only you can really know if your cheating.

There are other options for reducing hard stones, many of which will prove, unlike two twenty-nine blue, to mix quite well with the binding media. A more basic non mechanized option for very hard minerals is to rub them on a hard, but abrasive, flat stone with a small amount of water. The stone must be harder than the mineral and solid enough not to abrade away and contaminate the pigment.

Some mineral pigments are so fine and soft as to be easy to grind and readily soluble in water (good dispersion). Some can be scraped away with a sharp edge or even tossed straight into a small mortar and ground with a little water. A few may not even need to undergo any more processing.

Processing Pigments

The first step is to reduce the mineral into a fine powder. Harder minerals need to be ground, either on a flat rock or metate with a fist sized stone as the muller (mano) or in a mortar with a pestle. (If you don't have a mortar and pestle you might as well start making one. Just peck away with a harder stone until it's done.) In grinding anything, one sooner or later (hopefully sooner) hits a point of diminishing returns; that is to say, that the finer powder increasingly cushions and protects the coarser particles from being reduced. Knowing when to stop is a matter of experience but the concept is worthy of attention to anyone who does much grinding. More likely you will just stop when you're tired of grinding and think the powder seems fine enough anyhow.

Softer deposits may not require grinding at all, as is the case with many clay based pigments as well as clay for pottery. These can simply be mashed and stirred long enough in a bucket until they mostly dissolve.

The next step is to separate the small fine particles from the larger ones. **Settling** is a necessity for most pigments because they seldom are comprised of uniformly fine powder. In the process, impurities of sand and grit are also removed.

The settling process is simple. Whether ground or not, the pigment is stirred in water to disperse the color particles. There must be enough water to make a thin solution. (In a thicker solution, the coarser particles may remain suspended instead of falling to the bottom as we want them to.) After stirring, you wait for the coarse particles to settle to the bottom. How long? Good question. The pigment is of course in all sizes. The coarsest particles will settle first; then the rest will follow according to their mass. Usually five to ten seconds is long enough to wait for most purposes. The longer you wait, the finer the final product will be, but there will also be less of it.

Now, the liquid (with fine particles in suspension) is poured off into another container and allowed to settle. Don't pour off all of the liquor. Leave a good amount of liquid in the bottom or some of the coarse grit off of the bottom of the first container will be decanted with the finings. If you want you can add more water to the first container, stir again, and pour it off once more to gain a little more of the finings. Both the fine and coarse grits are then allowed to settle, after which the clear water is removed and the pigment evaporated until dry. The coarser particles (in the first jar) may then be reground and settled again.

Tamara Wilder

Soot collecting apparatus: An "ovenlike" ***arrangement, Top stone is lifted to show accumulatad soot (see photo) Fuel here is conifer pitch or resin soaked conifer wood (fat pine). Oils burned in lamps with a wick also work. The important part is to interrupt the flame preventing the carbon particles from being completely combusted. Known as lampblack this is the finest source of carbon particulate, being used in india hike (blocks and liquid) tattooing, and paints. Further burning in an airtight container destroys remaining oily material improving the product. Alcohol can assist dispersion of lampblack in water.***

For large batches, an option to pouring off is to just let the pigment solution settle into layers in a bucket. The ad-

more

vantage of this method is that it yields several layers of variously fine paint, which can be scraped up one at a time and stored separately.

The pigment may be used right away while still damp, stored away wet, or dried and stored for later use.

Using Mineral Pigments

In some cases paints may be used with no binder, simply rubbed or painted on wet or dry. For example, dry pigment can be rubbed into buckskin to give color, which looks nice but washes out easily. The finer the pigment, the better this method works. Another example would be using spit to apply some paint to an arrow shaft. Spit is actually more binding than water but not by much. If some animal fat, say bear grease, is added to the pigment, binding will be better.

The paint can sometimes be applied to the surface with only water, and then a sealer applied over this. **Parfleche** (painted rawhide) is made in this way. Using water as the only vehicle, color is applied to the flesh side of the wet skin and rubbed into the skin fiber. When painting is finished, a slime (made by soaking the pads of the prickly pear cactus (Opuntia species) in water) is applied several times to seal and protect the pigment. **Buckskin,** as well as the flesh side of fur-on robes, can be painted similarly- painting on dry skin with water and using dilute hide glue as the sealer/binder.

The mineral powder may, of course, be mixed with a binder and applied like paint. This method is especially useful for painting on less absorbent surfaces and will generally give the most opaque density to the painted area. However, there are limitations to the mixtures ability to bind to the object. It would be a mistake to apply a thick coat of paint to an object which is subjected to much flexing, because only the most flexible of paint bases will endure such treatment without peeling, chipping, and cracking; and very flexible paint bases are few and far between. For these reasons, the object to be painted should be assessed in regards to its use and the temptation to apply a very thick coat should be avoided in most cases. For very porous absorbent surfaces like buckskin, it can sometimes be detrimental to apply pigment already mixed with a binder, as the binder may actually inhibit the absorption of the color into the hide. Seeds of wild cucumber (Marah sp.), egg yolks, fish eggs, boiled beaver tails or wax from beaver tails, buffalo gall stones, peach or chokecherry gum, vitreous humor (a fancy name for eyeball juice), and resins of coniferous trees are all mentioned as sealers or binding media for painting on skins.These materials would all be used very dilute and some would only be used as a final sealer

For **body paints,** fat is the most universally used binder. One practical reason for body painting is as protection against sunburn. Fat can also be used as a binder on other objects.

It is also important to prepare the surface properly before you paint it. Rawhide will absorb color better when damp than when dry. Too wet, and the pigment may bleed. Buckskin seems to work best dry. Woods should not be polished too much or there will be little "tooth" for the binder to hold on to, and if anything but oil is used for the binder, the surface should be oil free.

We have mostly used animal **glue** (i.e. hide or sinew glue) as a paint base. It works well once the proportions of water to paint to glue are right, but holds the disadvantage of being soluble in warm water, A thin coating of liquid conifer sap, as in that from the blisters on certain species of fir and spruce can help seal against moisture, but be sure to apply them as thinly as possible and allow them to dry unmolested so that nothing undesirable will stick to them before they dry. Hide glue paint needs to be kept warm to flow and stick well. (For articles on making animal glue see SPT Bulletins #2, #8; #l 3 or Chapter 28 of ***Buckskin: The Ancient Art of Brain-Tanning*** by the authors.)

Hide glue or rabbit glue can usually be bought through art supply stores; a mail order source is given at the end of this article. You can also use clear unflavored uncolored gelatin available at grocery stores, which is essentially just food grade powdered hide glue.

Other binders which have been used through the ages include drying oils (like linseed oil, poppy oil; walnut oil),casein, and egg yolk. The **drying oils** are the standards for the well known method of oil painting. **Casein** (made from milk protein) has long been used as a paint base and is experiencing a sort of rebirth as a good non toxic house paint. Casein is not very water soluble and is dissolved in water with the help of other substances, most interesting of which is slaked lime. The resulting lime/casein is, upon drying, insoluble, a great advantage. Egg **yolk,** and sometimes the white as well, is another paint base much and long used. Many recipes exist for the use of egg yolk sometimes with lime to create a more insoluble glue, or in emulsions with oil, with animal glues...ad infinitum.

Recommended Materials Sources

***Synopia** (store and mail-order catalogue) 415-824-3180 Street Carries variety of pigments as well as animal glues, resins, books 3385 22nd St. SF, CA 94110*

***Natural Choice** ECO Design Co.) 1365 Rufina Circle Santa Fe, NM 87505. 505) 438-3448. Catalogue which carries earth pigments and casein paints,*

References

Cennini, Cennino #Andrea
1933 Libro dell'Arte (translated to English by Daniel Thompson under title The Crafisman 's Handbook. Yale University Press,
Danielson, Joanne (Geologist) Personal communication.
Doerner, Max
1934 The Materials of the Arfisf. Harcourt Brace & CO., New York.
Hurlbut Cornelius S.
1971 Dana's Manual of Minerology 18th Edition. John Wiley & Sons, Inc., New York.
Thompson, Daniel V
1947 The Practice of Tempera Painting Dover Publications, Inc., New York.
D. Van Nostrand Company Inc.,
1947 Van Nostrands Scientific Encyclopedia, New York.

Here is the most basic of egg tempera:

- Crack an egg and separate the yolk from the white by carefully transferring the yolk back and forth between the two halves of the shell allowing the white to ooze off into a bowl. Put the yolk into a cup or some such thing and add a couple of tablespoons of water-breaking the yolk and mixing all well.

- Grind some settled mineral pigment with a tiny bit of water to form a thin paste, a step which serves two purposes. 1) to grind the paint even finer and 2) to be sure that the mineral is intimately associated with the water so that no lumping occurs.

- Now egg and mineral are mixed together in about equal parts and stirred with a brush. Once mixed test the solution on an absorbent surface (an absorbent surface will speed drying). If, upon drying, the paint looks dull and flat add a bit more of the yolk. Testing again and so on until the paint dries with a slight sheen or gloss. Likewise, more mineral may be added to reduce a high gloss

- Finally, reduce the thickness of the paint with water so that it flows thinly. Better to have it flow thin and have to paint over it a couple of times, than to have it thick which risks running, uneven color density, and smearing.

- This basic tempera is water soluble, but, once dry, can be sealed over with an insoluble glaze. If slaked lime is added the tempera can be made more or less waterproof. Experiments by us along these lines have yielded mixed results, especially as regards finding and processing lime. Experiments will likely continue and may form the contents of a future article??? In the meantime, color it black, color it red, purple, or yellow, but just color it!

One more resource* that **you** *shouldn't miss:* <u>*Henlev's Twentieth Century Formulas. Recipes and Processes*</u>*> 14th edition. Norman W. Henley Pub. Co., New York, 1916. This and other old formula books are full of good information.

Steven and Tamara can be reached at Paleotechnics, PO Box 876, Boonville, CA 95415. 707-793-2287. They are the authors of the acclaimed <u>Buckskin: The Ancient Art of Braintanning...</u> $19.95 plus shipping from the authors.