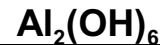


albany slip clay

Colorant	Fe
Flux	Ca, Mg, KNaO
Viscosity	Al
Glassfrmr	Si

No longer mined. Try using Blackbird or Barnard (slightly more fluxed), or see Oct. '88 CM article: dolomite 9, soda ash 1, Redart 90 to substitute.

alumina hydrate



Viscosity	Al
-----------	----

Hydrate form often used for wadding for vapor glazing.
Also supplied in calcined form.

barium carbonate BaCO_3 (raw) BaO (fired) barium sulfate BaSO_4 (raw) BaO (fired)

Flux	Ba
------	----

Carbonate form toxic if ingested or inhaled. No evidence of absorption thru unbroken skin. See article Ceramics TECHNICAL no. 3, 1996 by Janet DeBoos, p. 66. May leach from high or unstable Ba glazes. Makes satin matts except w/boron. Barium sulfate is almost completely insoluble and not a significant toxin.

Secondary flux. ½% in earthenware clay bodies to prevent scumming. High Ba + Cu = matt blues.

antimony



Colorant	Sb
----------	----

Colorant. Weak white, yellow w/lead.

bone ash $\text{Ca}_3(\text{PO}_4)_2$ (raw) • CaO (fired)

Flux	Ca (P) burns out
------	---------------------

+ traces of Mg, Al, Fe et al. Calcium phosphate. Secondary flux. Body flux in bone china. May give milky, mottled glaze color & encourages breaking from high spots. W/tin, less tin needed to opacify. P promotes red-brown Fe colors. Boiling from P may cause crawling & blistering, but can also promote oil spot colors. Can make lowfire foam glazes at about 20%.

bentonite

Viscosity Glassfrmr	Al Si
------------------------	----------

Volcanic, clay-like. Add up to 2% to help counter settling in glaze w/o changing fired result. Add to dry ingred. first & mix.

boric acid



F, V	B
------	---

Soluble source of boron. Toxic raw.

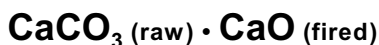
borax



Viscosity agent & Flux Flux.	B Na
---------------------------------	---------

Soluble. Gives bright color.

calcium carbonate



Flux	Ca
------	----

Whiting, chalk, lime, limestone. Main source of Ca (alkaline earth flux) for glazes. Helps produce hard glazes. Excess matts.

cadmium oxide

Colorant	Cd
----------	----

Oranges and reds. Toxic. Used primarily in stains. New "inclusion" stains manufactured by DeGussa or Cookson Matthey encapsulate Cd in Zr to stabilize and reduce solubility.

chrome oxide



Colorant	Cr
-----------------	-----------

Usually green, opaque. Cr + Zn = brown. Small amts. Cr + high tin = pink. Cr + Pb = orange, red, or yellow. Cr + alkaline flux = yellower green. Refractory, but volatile over about 1800° F. May cause skin and respiratory irritation.

cobalt carbonate CoCO_3 (lavender raw)

cobalt oxide Co_3O_4 (black raw)

CoSO_4 sulfate (lavender raw)

Colorant	Co
-----------------	-----------

Carbonate form slightly weaker, disperses better than oxide form. Cobalt sulfate is a soluble form, toxic. Strong blue. Ultramarine w/alkaline fluxes. Purple w/ Mg. Green w/Ti. All forms fire to CoO .

copper

CuCO_3 carbonate (gray-green to turquoise raw) • CuO oxide (red or black forms) • CuSO_4 sulfate

Colorant	Cu
-----------------	-----------

Toxic. Melts at low-fire temp. Volatile. Carbonate (green raw) weaker but disperses better than oxide form (black raw). Red copper oxide does not mix w/water. Copper sulfate is soluble & toxic. Red in reduction. Green oxidized. + alkaline flux = turquoise, + Pb = transp. grass green.

cristoballite

Glassfrmr	Si
------------------	-----------

Form of silica. Formed from free silica above about 1920°. Inversion of about 3% smaller at 439° F.

cryolite

Na_3AlF_6 (raw) $3\text{Na}_2\text{O} \cdot \text{Al}_2\text{O}_3$ (fired)

Flux Viscosity	Na, Al (F) burns off
---------------------------------	---

Sodium aluminum fluoride. Secondary flux, alkaline color response. May cause boiling of glaze and pinholes from F gas released in firing.

china clay

$\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2 \cdot 2\text{H}_2\text{O}$ (raw) • $\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2$ (fired)

Al Si	Viscosity Glassformer
------------------------	--

China clay, kaolin are purest forms of clay. Other clays may also contribute iron and trace minerals. May be added to glazes to raise the melting point and eventually matt. Some clay content in glazes helps the raw glaze stay on the pot better during glazing and loading. Usually any kaolin may be used in a clay calling for China clay.

clay

$\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2 \cdot 2\text{H}_2\text{O}$ (raw)

$\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2$ (fired)

Viscosity Glassfrmr	Al S
--------------------------------------	-----------------------

China clay, kaolin are purest forms. Other clays may also contribute iron and trace minerals. May be added to glazes to raise the melting point and eventually matt. Some clay content in glazes helps the raw glaze stay on the pot better during glazing and loading. EPK is the generic material for "clay" in a recipe.

colemanite

$2\text{CaO} \cdot 3\text{B}_2\text{O}_3$ (fired)

Flux Flux & viscosity agent	Ca B_2O_3
--	---

Calcium borate. No longer available in the U.S. Current substitute is gerstley borate, which contains Ca, B_2O_3 , and Na.

cornwall stone

$.304 \text{CaO} \cdot .340 \text{Na}_2\text{O} \cdot .356 \text{K}_2\text{O} \cdot 1.075 \text{Al}_2\text{O}_3 \cdot 8.10 \text{SiO}_2$

Flux Glassfrmr Viscosity	Ca, KNaO Si Al
---	---

Similar to feldspar, but w/ higher silica. Variable. May contain Fluorine. According to Hamer, Cornwall stone has less surface tension than feldspar in the melted state and is sometime used in place of spar to prevent crawling.

crocus martis



Colorant	Fe
-----------------	-----------

Natural form of iron, purplish raw. May give darker browns than red iron and black w/cobalt. Gives purplish-brown colors in sigillata.

epsom salts
MgSO₄ (raw) MgO (fired)

Flux	Mg
-------------	-----------

Magnesium sulfate. Soluble. Used in small amounts as a flocculent to help keep glazes from settling. Flocculation acts on clay particles to produce open "house of cards" structure where the particles orient end-to-middle

flint
SiO₂

Glassfrmr	Si
------------------	-----------

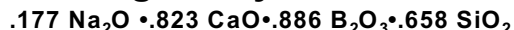
Flint, quartz. Major glass-former. Undergoes quartz inversion of 2% at 1000° F. Over 1938° F free silica may form cristoballite, which undergoes 3% inversion at 439° F.

frit

F. G. V	varies, but most frits contain flux, viscosity agent, and glassformer
----------------	--

Man-made. Ferro, Pemco, O'Hommel companies make a variety of frits for low-fire temperatures. See published lists or mfg. specification for contents.

gerstley borate



Flux V, Flux Glassformer	Ca, Na B Si
---	----------------------------

Substitute for colemanite. Named after a Calif. man who operated a colemanite mine. Boron is both flux and viscosity agent. Thixotropic.

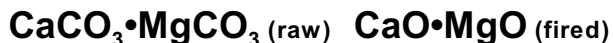
iron oxide FeO (black, ferrous)

iron oxide Fe₂O₃ (red, ferric)

Colorant	Fe
-----------------	-----------

Red iron is finer in particle size than black. Iron is usually tan to brown to red-brown in oxidation, but can also be amber in lead glazes, or glazes w/ Ba or Sr. Yellow to olive in high alkaline glazes. In reduction 1-6% w/calcium phosphate gives blues, ½ -3% with some calcium gives celadons, 10-15% Temmoku.

dolomite



Flux	Ca, Mg
-------------	---------------

Calcium magnesium carbonate. Hi temp flux.

feldspar



Flux Viscosity Glassfrmr.	KNa or Li Al Si
--	--------------------------------

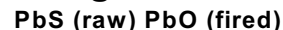
Flux: alumina: silica ratio approx. 1:1:6. Custer is a K spar, Kona F-4 a Na spar, Spodumene a Li spar. Used to flux clays and glaze at high temps.

fluorspar CaF₂ (raw) CaO (fired)

Flux	Ca (F) burns off
-------------	-----------------------------

Fluorine burns off in firing, may cause boiling and pinholing over 5%. Fluid melts at low temps. May cause unusual blues w/Co and Cu. According to Ceramic Industry: "During firing fluorspar in contact w/silica and clay is thought to dissociate into gaseous SiF₄. The volatile fluoride may in time promote destruction of kiln refractories."

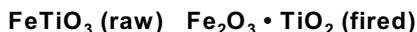
galena



Flux	Pb
-------------	-----------

Lead sulfide. Toxic.

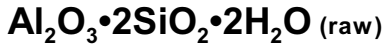
ilmenite



Colorant Opacifier	Fe Ti
-------------------------------	------------------

In granular form, causes speckles. Effects similar to rutile. Variable material. Formula above is a typical sample.

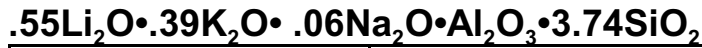
kaolin



Al Si	Viscosity agent Glassformer
----------	--------------------------------

See clay. For generic uses of kaolin, EPK is often used. Refractory. Can be added to stiffen a runny glaze. If enough is added, it will cause matting and raise the melting temp.

lepidolite



Flux Viscosity Glassfmr.	Li, Na Al Si
--------------------------------	--------------------

Similar to feldspar. Li content may cause shivering in excess.

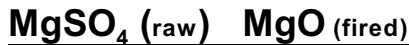
Macaloid



Flux Glassfmr	Li, Mg Si
------------------	--------------

Synthetic bentonite. Does not bloat in water like bentonite, so it may be added directly to liquids.

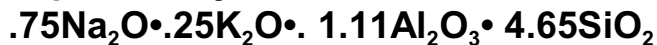
magnesium sulfate



Flux	Mg
------	----

Soluble. Used in small amounts as a flocculent to help keep glazes from settling. Flocculation acts on clay particles to produce open "house of cards" structure where the particles orient end-to-middle.

nepheline syenite



Flux Viscosity Glassfmr.	KNa Al Si
--------------------------------	-----------------

Similar to feldspar but more KNa to Si, so it melts lower than spar..

iron chromate



Colorant	Fe, Cr
----------	--------

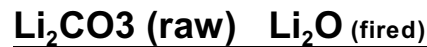
Source of iron and chrome. Taupe in slips.. McKee says use 4% iron chromate + 4% copper to make black.

lead oxide

Flux	Pb
------	----

Toxic. White, red, and yellow lead, galena, litharge and lead chromate are sources. Lead frits are safer to handle in studio than raw lead. Final safety depends on glaze chemistry. Active at low temp - cone 6. Blisters if reduced. Soft glazes, easily abraded or attacked by acids. Volatilizes in firing. + Cu = transparent grass green. + Fe = amber. + Cr = yellow, red, orange. + Cd = red.

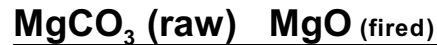
lithium carbonate



Flux	Li
------	----

Active low - high temperatures. Alkaline flux. Low coefficient of expansion. Soft glaze, may produce matt crystals. May cause shivering in excess. Lithium carbonate will deflocculate glazes and cause them to settle in the bucket.

magnesium carbonate



Flux	Mg
------	----

Source of Mg, alkaline earth flux. High temp flux. Buttery matts, pastels colors. + Co = purple.

manganese

MnO oxide



Colorant	Mn
----------	----

Toxic. Carbonate is weaker but disperses better than oxide or dioxide form. Brown. Toward purple w/alkaline flux, lead. Used fritted w/alumina to make pink stain (Mason 6020, which is refractory and goes to cone 10). Can be metallic in high amounts with copper.

ochre

Colorant	Fe
----------	----

A natural source of iron (about 50%), mixed with clay and sand. May also contain manganese. Weaker than using iron.

plastic vitrox

$.054\text{Na}_2\text{O} \cdot .842\text{K}_2\text{O} \cdot .045\text{CaO} \cdot .058\text{MgO} \cdot 1.693\text{Al}_2\text{O}_3 \cdot 14.634\text{SiO}_2$

Flux Viscosity Glassfmr.	KNaO, CaO, MgO Al Si
--------------------------------	----------------------------

Resembles feldspar, but has more silica to flux and alumina than spar

potassium carbonate

K_2CO_3 (raw) K_2O (fired)

Flux	K
------	---

Pearl ash. Soluble source of potassium. Potassium carbonate. Deflocculates clay slips. Slightly caustic.

pyrophyllite

$\text{Al}_2\text{O}_3 \cdot 4\text{SiO}_2$

Viscosity Glassfmr.	Al Si
------------------------	----------

Decreases thermal expansion.

rutile TiO_2

Colorant Opacifier	Fe Ti
-----------------------	----------

Broken opaque color, crystals from Ti. Other impurities present in small amounts are Fe, Cr, Vn. Suppliers sometimes carry light and dark varieties of rutile. Dark contains more iron.

nickel oxide (green) NiO

nickel oxide (black) Ni_2O_3

nickel carbonate NiCO_3 (raw) NiO (fired)

Colorant	Ni
----------	----

Toxic. Carbonate and oxide (black or green raw) forms. Used to produce subdued green, grey, brown, or blue. and to modify other colors (e.g. mute cobalt blues). In high Mg glazes, acid green may develop. In high Ba glazes, pink to purple.

pearl ash

K_2CO_3 (raw) K_2O (fired)

Flux	K
------	---

Potassium carbonate. Soluble source of potassium. Potassium carbonate. Deflocculates clay slips. Slightly caustic.

potassium bichromate

$\text{K}_2\text{Cr}_2\text{O}_7$ (raw) K_2O , Cr_2O_3 (fired)

Colorant Flux	Cr K
------------------	---------

Very toxic. Soluble. Olive greens generally, behaves like chrome w/ fluxes. Bright orange raw.

praseodymium

PrO_2 (raw & fired)

Colorant	Pr
----------	----

Toxic. Colorant used to make yellow stains. Stable @ high temps in oxidation or reduction.

quartz

SiO_2 (raw & fired)

Glassfmr.	Si
-----------	----

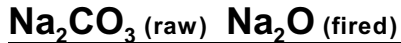
Flint, silica. Primary glassformer in glazes.

silica SiO₂

Glassfmr.	Si
-----------	----

Flint, quartz. Glass-former.

soda ash

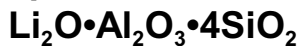


Flux	Na
------	----

Sodium carbonate. Soluble source of sodium. Alkaline flux, high coefficient of expansion. Makes soft glaze.

Deflocculates: acts on clay particles to cause particles to align parallel and slightly repel each other; effect is to make things more liquid with less water.

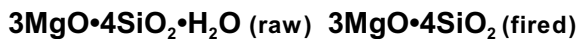
spodumene



Flux Viscosity Glassfmr.	Li Al Si
--------------------------------	----------------

Lithium feldspar. Reduces thermal expansion. In clay bodies good for ovenware. In glazes too much may cause shivering due to low expansion of Li.

talc



Flux Glassfmr.	Mg Si
-------------------	----------

Magnesium silicate. Secondary flux. Often a body flux at low temps, due to eutectic amounts of ingredients. Reduces crazing. Smooth, buttery glaze surfaces, Mg color responses. Chronic inhalation causes lung scarring. Some talcs may be contaminated by asbestos or asbestos-like minerals. Check with your supplier.

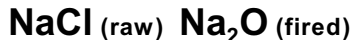
titanium dioxide



Opacifier	Ti
-----------	----

Opacifier. Often produces crystalline matts. + Co = green. W/Cu reds = toward purples. 2% added to glaze can give microcrystalline formations & interesting colors.

salt



Flux	Na
------	----

Soluble. Salt. Soluble form of sodium. Alkaline flux, high coefficient of expansion. Makes soft glaze.

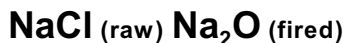
silicon carbide



Glassfmr.	Si
-----------	----

Also known as carborundum. Causes local reduction if fine (200 mesh)(.5%), crater glazes if coarse (2-5%?).

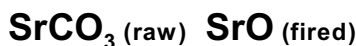
sodium chloride



Flux	Na
------	----

Salt. Soluble form of sodium. Alkaline flux, high coefficient of expansion. Makes soft glaze.

strontium carbonate



Flux	Sr
------	----

Alkaline earth flux. Active primarily at high temperatures. Behaves similar to calcium and barium. Try .75 SrCO₃ to replace 1 barium in glazes for less toxic ingredient.

tin oxide



Opacifier	Sn
-----------	----

Stannic oxide. Opacifier. High tin + small amts. Cr = pink. + Fe = orange to red. High tin may cause crawling. Buttery surface. 1 tin = 1.5 zirconium opacifier in strength.

uranium oxide



Colorant	U
----------	---

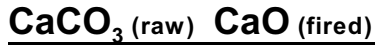
Toxic. Yellow, red, orange colors with lead. Yellow w/alkaline flux. Rarely used. Often unavailable for casual use.

umber

Colorant	Fe, Mn
----------	--------

Contains iron + manganese. Raw umber is unheated. Burnt umber is calcined.

whiting



Flux	Ca
------	----

Calcium carbonate. Calcium is an alkaline earth flux, good for making hard glazes (i.e. good for tableware).

vanadium pentoxide



Coiorant	V
----------	---

Weak yellow colorant, stronger source of yellow color when made into a stain with tin or zirconia. Inhalation and ingestion hazard.

zinc oxide



Flux	Zn
------	----

Metallic flux, mid- high temps. In large amts. (Over 25%) may cause crawling, pin holes, dry surfaces, opacity. Calcining the Zn may help. Zn + Cr= brown. Zn good for Co blues.

wollastonite



Flux Glassfmr.	Ca Si
-------------------	----------

A calcium silicate. May be used to replace whiting and flint.

zirconium oxide



Opacifier	Zr
-----------	----

Opacifies. Produces harder glaze than Sn or Ti. Less strong than tin (general rule: 1 Sn = 1.5 Zr opacifier). Trade names: Ultrox (all temps., stronger than Zircopax. 6% = white), Superpax, Zircopax (all temps., 5-10% = white), Opax (best at lower temps.).