alumina
oxide Al_2O_3
alumina
hydrate $Al_2(OH)_6$

bone ash A1
$Ca_3(PO_4)_2$

Albany slip clay
$0.059\ Na_2O \bullet\ 0.156\ K_2O \bullet\ 0.309\ MgO \bullet\ 0.476\ CaO \bullet\ 0.659\ Al_2O_3 \bullet\ 4.42\ SiO_2 \bullet\ 0.023\ TiO_2 \bullet\ 0.15 Fe_2O_3 \bullet\ 2.399\ H_2O$

borax (soluble)
$Na_2O \bullet 2B_2O_3 \bullet 10H_2O$

antimony oxide Sb_2O_3

boric acid (soluble)
$B_2O_3 \bullet 3H_2O$

barium
carbonate $BaCO_3$
sulfate $BaSO_4$

cadmium
carbonate $CdCO_3$
sulfide CdS

Bentonite
$Al_2O_3 \bullet 4SiO_2 \bullet H_2O$

Cadycal

Calcium phosphate. Contributes the alkaline earth flux, calcium; P burns out in firing, promotes red- brown Fe colors. May give milky, mottled glaze color & encourages breaking from high spots. Secondary flux. Body flux in some European china. W/tin, less tin needed to opacify. May cause crawling & blistering due to boiling during firing. Can make lowfire foam glazes at about 20%. **Q1**	Hydrate form often used for wadding for vapor glazing. Also supplied in calcined form. Refractory. Used in wax resist to wax pot galleries, etc. and keep highly-fluxed clays from sticking to each other in firing.
Soluble source of sodium and boron. Gives bright alkaline color. Sometimes used w/salt in vapor glazing for lower-firing, glassy glaze.	A slip glaze clay at high fire temperatures. No longer mined. Try using Blackbird or Barnard (slightly more fluxed), or Alberta .
Soluble source of only boron. Toxic raw.	Colorant. Weak white, yellow w/lead. Used to make Naples yellow. Highly toxic by inhalation.
Colorant. Not useful for the studio potter in raw form. Oranges and reds with lead in low-fire stains with a limited firing range, burns out to grey above 05. Toxic raw, toxic fumes in firing. New “inclusion” stains encapsulate colorant in Zr to stabilize (will go to cone 10) and reduce solubility. Do not ball mill inclusion stains.	Alkaline earth flux, active primarily at high temps. Carbonate toxic if ingested or inhaled. No evidence of absorption thru unbroken skin. May leach in high amts or unstable glazes. Not suggested for food wares. Makes satin matts except w/boron. Sulfate is almost completely insoluble and not a significant toxin. Secondary flux. ½% in earthenware clay bodies to prevent scumming. High amt + Cu = matt blues in oxidation or reduction.
Calcium borate mineral produced by Fort Cady Minerals Corp of Newberry Springs, CA. Twice as much boron as Gerstley. GB glazes depend on its thixotropic properties for suspension, hardness and flow properties, but Cadycal will not impart these.	Volcanic, clay-like. Add up to 2% to help counter settling in glaze w/o changing fired result, or as a plasticizer in clay bodies. Bloats in water: add to dry ingred. first & mix, then add water. Seldom used above 2%.

calcium carbonate
$CaCO_3$

cobalt A2
carbonate $CoCO_3$ (lavender raw)
oxide Co_3O_4 (black raw)
sulfate (soluble) $CoSO_4 \bullet 7H_2O$ (lavender crystals raw)

china clay $Al_2O_3 \bullet 2SiO_2 \bullet 2H_2O$

Colemanite $2CaO \bullet 3B_2O_3 \bullet 5H_2O$

chromium
oxide Cr_2O_3 raw form green

copper
carbonate $CuCO_3$ (gray-green to turquoise raw)
oxide black CuO
oxide red Cu_2O
sulfate $CuSO_4 \bullet 5H_2O$ (pale turquoise crystals raw)

clay
$Al_2O_3 \bullet 2SiO_2 \bullet 2H_2O$
ideal formula

Cornwall stone
.304 CaO• .340 Na_2O• .356 K_2O• 1.075 Al_2O_3• 8.10 SiO_2

CMC gum

cristoballite

Strong colorant. Melts at low-fire temperatures. **Q2** Expensive. Carbonate form (lavender raw) slightly weaker, disperses better than oxide form (black raw). Cobalt sulfate is a soluble form, toxic. Gives strong blue colors, transparent if dilute. Ultramarine w/alkaline fluxes. Purple w/ Mg. Green w/Ti. Screen glazes containing Co well to avoid spotting. Concentrated use of Co spits in firing, leaving blue halos on kiln shelves and adjacent wares.	Whiting, chalk, lime, limestone. Main source of Ca (alkaline earth flux) for glazes. Helps produce hard glazes. Excess matts.
Calcium borate. Contributed only calcium and boron to a fired glaze. No longer available. Substitute Gerstley borate.	Synonymous with kaolins, the purest forms of clays. May be added to glazes to raise the melting point, reduce flow, and eventually matt. Some clay in glaze aids application of raw glaze. Toxic if inhaled: inhalation of dry clay can cause silicosis (from free silica in clay) or kaolinosis of the lungs.
Colorant. Melts at low-fire temperatures, so may also flux in higher amts at hi temps. Volatile above cone 8. Carbonate (green raw) weaker but disperses better than oxide form (black raw). Red oxide does not mix w/water. Sulfate (a.k.a. blue vitriol) is soluble & toxic. Red in reduction. Green to green-blue oxidized. + alkaline flux = turquoise, + Pb = transp. grass green. High amounts give gun-metal metallic greys.	Colorant. Most common color = opaque, dense green. + Zn = brown. Small amts. + high tin = pink. + Pb = orange, red, or yellow. + alkaline flux = yellower green. Refractory, but volatile over about 1800º F, so it may fume high (5%+) tin glazes to pinking. May cause skin and respiratory irritation. Colorant in well-know Otto's Texture sculpture glaze.
Similar to feldspar, but w/ higher proportion of silica than spar. May contain fluorine. Variable material. Melting range 2100° F to 2450° F, depending on the sample. For greater accuracy, obtain an analysis of the specimen being used. De-fluorinated Cornish stone is known as D.F. stone. Hamer says Cornwall stone has less surface tension than feldspar in the melted state and is sometime used in place of spar to prevent crawling.	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, reduce flow, and eventually matt. Some clay in glaze aids application of raw glaze. Ball clay used to make harder raw surface for better handling before firing. For a raw glaze that cracks in drying, add part of the clay as calcined clay. Toxic if inhaled: inhalation of dry clay can cause silicosis (from free silica in clay) or kaolinosis of the lungs.
Form of silica. Formed from free silica above about 1938°. Inversion of about 3% at 439º F. Excess may cause dunting in wares. Heat re-fired ware, especially high-fire ware, slowly past the inversion point to avoid cracking the ware.	Sodium carboxymethylcellulose. Organic gum used as a binder, surface hardener, and plasticizer. Aids brushability, counters settling in glazes. Decomposes in solution unless a preservative is added, e.g. formaldehyde, Canguard, Vancide (available from some ceramic suppliers). Excess can cause crawling. Available in powder or liquid form (syrup). Slake ½ cup dry CMC to 5 ½ cups boiling water overnight, then mix in a blender. Will be thick. Thin to a heavy syrup.

crocus martis $FeSO_4$	**feldspar** **A3** $KNaO• Al_2O_3• 6SiO_2$ Idealized formula
cryolite $Na_3•AlF_6$	**Flint** SiO_2
dolomite $CaCO_3•MgCO_3$	**Fluorspar** CaF_2
Epsom salts magnesium sulfate $MgSO_4•7H_2O$	**frit** various formulas. See mfg info
erbium oxide	**galena** PbS

Common mineral in crystalline rocks. Flux: alumina: **Q3** silica ratio approx. 1:1:6. Flux may be sodium-donminated, potassium-dominated, or lithium Used to flux clays and glaze at high temps. Most commercial varieties have traces of Fe and Mg.	Natural form of iron, purplish raw. Alone, dissociates at 2192°F. May give darker browns than red iron and black w/cobalt in glazes. Gives purplish-brown colors in sigillata:.
Also known as silica, quartz. Major glass-former. Single oxide source of silica. Undergoes quartz inversion of 2% at 1000º F. Over 1938º F free silica may form cristobalite, which undergoes 3% inversion at 439º F.	Sodium aluminum fluoride. Secondary flux, alkaline color response. May cause boiling of glaze and pinholes from F gas released in firing. Used in the production of opal glass, forms low-melting eutectics, potentially supplying alumina in low-melting form.
Calcium fluoride. Source of the alkaline earth flux calcium. Fluorine burns off in firing, may cause boiling and pin-holing over 5%. Fluid melts at low temps. May cause unusual blues w/Co and Cu. The volatile fluoride may in time promote destruction of kiln refractories.	Calcium magnesium carbonate. Hi temp flux. Ca and Mg properties: soft, buttery matts, pastels colors, gives purple colors w/Co due to Mg.
Man-made fluxes that melt between 1400-1700□F. Ferro, Pemco, O'Hommel companies make a variety of compositions for low-fire temperatures. See published lists or mfg. specification for contents and substitutions. Ferro 3300 and 3400 and Pemco Pb series contain Pb (lead).	Also known as magnesium sulfate. Soluble. Used in small amounts (e.g. 1 tbs per 10,000 grams of wet glaze) as a flocculent to help keep glazes from settling. Not generally used as a glaze source of Mg in glazes due to amount of S and action as flocculent.
Lead sulfide. Toxic. Historic source of lead.	Rare earth oxide colorant. Raw: pink powder. Produces pale, translucent pink. It can neutralize discoloring impurities such as ferric ions and produce a neutral gray shade. Gives its best pink color at concentrations of 8-10%, but it is difficult to get more than 8% to fully dissolve in the melt. It has given a more lavender color in the presence of iron traces in reduction.

Gerstley borate
Na_2O .177• CaO.823• B_2O_3 .886 • SiO_2 .658 + 3.049 Loss on Ignition

Lepidolite A4
.55Li_2O•.39K_2O• .06Na_2O•Al_2O_3• 3.74SiO_2

ilmenite
FeO•TiO_2

lithium carbonate
Li_2CO_3

Iron
oxide black FeO (ferrous)
oxide red Fe_2O_3 (ferric)
chromate $FeCrO_4$

Macaloid
Li_2O•MgO•SiO_2

kaolin
Al_2O_3•2SiO_2•2H_2O

magnesium carbonate
$MgCO_3$

lead
carbonate 2$PbCO_3$•$Pb(OH)_2$
monosilicate 3PbO•2SiO_2
oxide litharge
oxide red Pb_3O_4
sulfate (galena)

magnesium sulfate
$MgSO_4$•7H_2O

Source of lithium, KNaO, alumina and silica in a 1:1: 3.74 ratio. Similar to feldspar. Li content may cause shivering in excess. **Q4**	Source of sodium, calcium, boron, and silica. Thixotropic . Popular flux for lowfire glazes. Substitute for colemanite. Boron is both flux and viscosity agent.. Mining ceased in 1999.
Single- oxide source material that provides only lithium. Alkaline flux. Active low - high temperatures. Low coefficient of expansion. May cause shivering in excess. Produces a mechanically soft glaze, matt crystalline surfaces. Will deflocculate glazes and cause them to settle in the bucket.	Colorant contains iron (in greater amounts than rutile) and titanium. Opaque black mineral raw. In granular form, causes speckles. Effects similar to rutile: causes broken, mottled color, crystalline surfaces, opacity, golden-to-tan colors in oxidation, may be blue-purple-pink in reduction in small amounts.
Synthetic version of bentonite. More expensive. Doesn't bloat in water so can be directly mixed into liquids. Used as a glaze additive.	Colorant. Melts at low-fire temperatures. Red form is finer in particle size than black. 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.
Single-oxide source material of only Mg, alkaline earth flux. High temp flux. Buttery matts, pastels colors. + Co = purple.	Primary clay, pure, white, refractory. Synonymous with China clay, the purest forms of clays. May be added to glazes to raise the melting point, reduce flow, and eventually matt. Some clay in glaze aids application of raw glaze. Go-to material for a generic recipe request is EPK. Toxic if inhaled: inhalation of dry clay can cause silicosis (from free silica in clay) or kaolinosis of the lungs.
A.K.A. Epsom salts. Soluble. Used in small amounts (e.g. 1 tbs per 10,000 grams of wet glaze) as a flocculent to help keep glazes from settling.	Metallic flux. Soft glazes, easily abraded or attacked by acids. Toxic, accumulative poison, esp. by ingestion or inhalation. May leach from fired glaze in the presence of acid foods. White , red, and yellow forms, galena, litharge and chromate form are sources. frits are safer to handle in studio than raw material. Final safety of a glaze depends on glaze chemistry. Active at low temp - cone 6. Blisters if reduced. Volatilizes in firing, boils off by cone 6. + Cu = transparent grass green. + Fe = amber. P + Cr = yellow, red, orange. + Cd = red.+ Mn = plum

manganese
dioxide MnO_2
carbonate $MnCO_3$

Petalite A5
$Li_2O• Al_2O_3• 8SiO_2$

nepheline syenite
$.75Na_2O•.25K_2O•. 1.11Al_2O_3• 4.65SiO_2$

plastic vitrox
$.045CaO•.058MgO• .054Na_2O•.842K_2O• 1.693 Al_2O_3• 14.634SiO_2$

nickel
oxide (green)NiO
oxide (black)Ni_2O_3

potassium carbonate
K_2CO_3

ochre
various formulas

potassium dichromate
$K_2Cr_2O_7$ (bright orange raw)

pearl ash
K_2CO_3

praseodymium
oxide PrO_2

Flux. Lithium-aluminum silicate (1:1:8). **Q5** M.p. 2552°F. Considered a lithium-fluxed feldspar. Low thermal expansion when heated above 1832deg F. Used as an auxiliary body flux to reduce thermal expansion and increase thermal shock resistance. Source of lithium for glazes.	Colorant. Toxic. Melts well at lowfire temperatures. Carbonate is weaker but disperses better than oxide or dioxide form. Browns. 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, e.g. Reynolds Gold Metallic glaze.
Resembles feldspar, but has more silica to flux and alumina than spar. Idealized formula is $1RO \bullet 1.69\ Al_2O_3 \bullet \underline{14}.64\ SiO_2$	Flux. Similar to feldspar but more KNa to Si(spar has flux:alumina:silica ratio of 1:1:6; this ,material is 1:1:4 ratio), so it melts lower than spar. Popular for mid-range materials. Somewhat soluble, deflocculates clays and glazes. Substituting this material in place of spar would be a place to begin testing lowering a hi-temp glaze to mid-range.
A.K.A. pearl ash. Flux. Soluble source of potassium, an alkaline flux. Deflocculates clay slips. Slightly caustic.	Colorant. Refractory. Toxic. Carbonate and oxide (black or green raw) forms. Used to produce subdued green, grey, brown, or blue under specific conditions, 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.
Colorant. Very toxic. Soluble. Olive greens generally, behaves like chrome w/ fluxes. Used in glaze to produce Cr-Sn pinks. In glazes w/o Sn or Zn, gives olive drab colors.	A natural, impure source of iron (about 50%), mixed with clay and sand. May also contain manganese. Weaker than using iron. Come in Yellow, reds, or browns.
Toxic. Colorant used to make brilliant yellow stains (pale yellow toward yellow-green). Stable @ high temps in oxidation or reduction.	A.K.A. potassium carbonate. Flux. Soluble source of potassium, an alkaline flux. Deflocculates clay slips. Slightly caustic.

pyrophyllite Al_2O_3• 4SiO_2• H_2O	**silicon carbide** A6 SiC
Quartz SiO_2	**sodium silicate** Na_2O•SiO_2
rutile TiO_2	**soda ash** Na_2CO_3
Salt NaCl	**sodium chloride** NaCl
silica SiO_2	**spodumene** Li_2O•Al_2O_3•4SiO_2

Also known as carborundum. Causes local reduction if fine (200 mesh)(.5%), crater glazes if coarse (2-5%?). Q6	Provides alumina and silica 1:4. Decreases thermal expansion. Non-plastic ingredient. Used as a filler in porcelain bodies, said to strengthen, but not proven in practice. Used in place of flint in a clay body.
A.K.A. water glass. Strong deflocculant. Usually sold in liquid form. Water glass is used as a glue, to preserve eggs w/o refrigeration, and as a fireproofer	Also known as silica, flint. Major glass-former. Single oxide source of silica. Undergoes quartz inversion of 2% at 1000º F. Over 1938º F free silica may form cristobalite, which undergoes 3% inversion at 439º F.
Soluble sources of sodium. Dissolves more readily in warm water. Alkaline flux, high coefficient of expansion causes crazing in high amounts, brilliant color response. Sodium makes a mechanically soft glaze as a major flux. Deflocculates. Na + Co ultramarine. Na + Cu = transp. turquoise Na + Cr + chartreuse. Na + Mn = plum. Used as rock salt in salt-glazing where Na combines w/the silica in clay to form a hard, durable glaze.	Broken opaque color, crystals from Ti. Iron, other impurities (Cr, V)present. Suppliers sometimes carry light and dark varieties of rutile. Dark contains more iron.
A.K.A. salt. Soluble source of alkaline flux sodium + materilal that burns off as a gas. Sometimes used for vapor-glazing.	Soluble source of alkaline flux sodium + chloride that burns off as a gas. Sometimes used for vapor-glazing.
Lithium feldspar: provides lithium, alumina, and silica 1:1:4. Reduces thermal expansion. Good for ovenware clay bodies. In glazes too much may cause shivering due to low expansion of Li.	Also known as flint, quartz. Major glass-former. Single oxide source. Undergoes quartz inversion of 2% at 1000º F. Over 1938º F free oxide may form cristobalite, which undergoes 3% inversion at 439º F.

strontium carbonate $SrCO_3$	**uranium oxide** A7 U_3O_8
talc $3MgO•4SiO_2•H_2O$	**vanadium pentoxide** V_2O_5
tin oxide SnO_2	**whiting** $CaCO_3$
titanium dioxide TiO_2	**wollastonite** $CaO•SiO_2$
umber various formulas	**zinc oxide** ZnO

Colorant. Toxic. Yellow, red, orange colors with lead. Yellow **Q7** w/alkaline flux. Rarely used. Unavailable for casual use. Colorant used in famous orange Fiesta ware.	Alkaline earth flux. Single oxide source material. Behaves similarly to barium – makes matts, + Cu = robin's-egg blues. Promotes amber colors from iron. Test 0 .75 replaces 1 barium carb in glazes for less toxic ingredient.
Weak yellow colorant, makes warm yellow colors. Stronger source of yellow color when made into a stain with tin or zirconia. Inhalation and ingestion hazard.	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 may be contaminated by asbestos or asbestos-like minerals.
Calcium carbonate, chalk, lime, limestone. Main source of Ca (alkaline earth flux) for glazes. Helps produce hard glazes. Excess matts.	Stannic oxide. Opacifier. High amounts (over about 5%) + small amts. Cr = pink. + Fe = orange to red. High amounts may cause crawling. Buttery surface. 1 of this opacifier = 1.5 zirconium opacifier in strength. Opacifier in historic majolica glazes.
A calcium silicate. May be used to replace whiting and flint.	Opacifier. Often produces crystaline matts. + Co = green. W/Cu reds = toward purples. 2% added to glaze can give microcrystalline formations & interesting colors. 1 TiO_2 + 1 Gerstley borate (by vol) used as a "patina" over fired terra sigillata is ivory to light yellow.
Metallic flux, mid- high temps. In large amts. (0ver 25%) may cause crawling, pin holes, dry surfaces, opacity. Calcining the Zn may help prevent shrinkage during early heating that promotes crawling. Potential for sculpture glaze use. Zn + Cr= brown. Zn good for Co blues. Completely volatilized in cone 10 reduction, so it does not contribute as a flux to the fired glaze. See ClayArt archives for discussion.	Colorant. Contains iron + manganese. Raw is unheated. Burnt is calcined.

zirconium oxide ZrO_2	**A8**

Q8	Modern opacifier, often used in the silicate form. Produces harder glaze than other opacifiers. Less strong opacity than the historic opacifier because it's more soluble in glaze. Produces a more translucent white, and a slightly shinier surface. Acts as both an inert particle suspended in the glaze and a re-crystallized opacifier. Refractory, often used in kiln wash. Low coefficient of expansion: counters crazing. Increases glaze viscosity, surface tension, and > 10% mechanical hardness. Best results in glazes high in Ca and low in boron.