FLUXES

Glaze Materials: Glaze is a layer of glass fused to a clay body, composed of a glass-former, fluxes, and viscosity agents.

GLASS-FORMERS (RO_2)
Silica (SiO_2) is the major glass-former. Refractory, but forms eutectics w/many fluxes. Low coefficient of expansion, used to adjust crazing. Makes glaze harder, more durable. **Sources:** FLINT (a.k.a. quartz) as a pure source, or silica combined w/other ingredients in FELDSPAR, FRIT, TALC, CLAY, NEPHELINE SYENITE, CORNWALL STONE, PYROPHYLLITE, AND WOLLASTONITE.

VISCOSITY AGENTS (R_2O_3)
Alumina (Al_2O_3) is the major viscosity agent. Refractory. Inhibits crystal growth and devitrification. **Sources:** ALUMINA HYDRATE as a pure source or alumina, or combined with other materials in FELDSPAR, CLAY, FRIT, NEPHELINE SYENITE, CORNWALL STONE, PYROPHYLLITE. **BORON** is both a flux and viscosity agent.

FLUXES (RO, R_2O)
Alkaline fluxes: SODIUM, POTASSIUM, LITHIUM
Alkaline earths: CALCIUM, BARIUM, STRONTIUM, MAGNESIUM
Metallic fluxes: LEAD, ZINC
+ Classified as a viscosity agent, also acts as a flux: BORON

Flux	Active temp.	Characteristics	**Sources** (*soluble)
SODIUM Na_2O alkaline flux Note: **KNaO** is shorthand for ANY combination of sodium and/or potassium.	low-high	▪ similar to potassium but a bit more active ▪produces soft glaze surfaces that are easily abraded or attacked by acids ▪high coefficient of expansion (crazes) ▪brilliant color: Cu = turquoise, Mn = purple, Co = ultra-marine blue, Cr = yellow green, chartreuse w/ small amounts of Cr ▪slightly more active than K or Li	SODA ASH * SALT * SODIUM BICARBONATE * FELDSPAR (Kona F-4) FRIT (may be part soluble) NEPHELINE SYENITE CORNWALL STONE CRYOLITE
POTASSIUM K_2O alkaline flux	low-high	▪similar to sodium, generally, but a bit less active	PEARL ASH * FELDSPAR (Custer) FRIT (may be part soluble) NEPHELINE SYENITE CORNWALL STONE

Flux	Active temp.	Characteristics	**Sources** (*soluble)
LITHIUM Li_2O alkaline flux	low-high	▪similar to KNaO, but has a low coefficient of expansion (excess may cause shivering) ▪ like KNaO, makes mechanically soft glazes ▪ small amounts (1%) may help smooth glossy glazes, more creates devitrification and matte crystalline surfaces ▪increases glaze fluidity ▪ begins fluxing at 1472 ^{o} F (800^{o} C) and is useful at all temperatures. Expensive, so at high temps cheaper fluxes may be better choices ▪ may halo at the edge of the glaze ▪ gasses as it decomposes and may cause pinholing	LITHIUM CARBONATE (may deflocculate glazes) Li FELDSPARS (Spodumene, Lepidolite, Petalite, Amblygonite) FRIT (Fusion F79, F134, F493, F582 Pemco P-2P36, Ferro FB-276-P-2) MACALOID
LEAD PbO metallic flux	low-med	volatilizes @ cone 6 ▪blisters in reduction ▪med. coeff. of expansion ▪soft glaze, may be leached w/acids ▪poisonous raw, may be leach toxic amts. in the fired state ▪warm color response: + Fe = amber, warm brown.+ Cd & Se = red.+ Mn = plum. + Cr = orange. + Cu = grass green transp.	WHITE LEAD RED LEAD LITHARGE GALENA LEAD CHROMATE FRIT (eg. Ferro 3300 or O'Hommel Pb series)
ZINC ZnO metallic flux	med-high	▪low coeff. of expansion (in small amts. decreases crazing) ▪high Zn opacifies and matts ▪excess may cause crawling ▪promotes crystals w/Ti & low Al ▪nice Co blues, muddy Fe browns, + Cr = brown. + Cu = bluish green ▪In cone 10 reduction, Zn is completely volatilized.	ZINC OXIDE CALCINED ZINC OXIDE FRIT
CALCIUM CaO alkaline earth flux	high	▪produces hard glaze ▪helps thermal shock resistance ▪favors celadon greens in reduction ▪NOT good for Cu red ▪excess will matt or cloud ▪forms eutectics often in small amounts ▪+ Cu = toward green in low temp. oxidation.	WHITING DOLOMITE BONE ASH WOLLASTONITE FLUROSPAR FELDSPAR FRIT GERSTLEY BORATE CEMENT PLASTER

Flux	Active temp.	Characteristics	**Sources** (*soluble)
BARIUM BaO alkaline earth flux	high	▪not very active flux ▪good matting agent ▪Ba + B form eutectic & will not mat ▪hardens glaze ▪*toxic* raw, may leach in high Ba matt glazes. See article by Janet DeBoos in Janet DeBoos Ceramics Technical #3 (1997). Not recommended for food ware. Substitute .75 $SrCO_3$ instead. ▪good for Cu reds in reduction ▪Cu + high Ba = matt blue even in reduction. + Fe = blues in reduction. + Cr = warmer opaque green. + Co = purple-blue.	BARIUM CARBONATE FRIT
MAGNESIUM MgO alkaline earth flux	high	▪not very active flux ▪good for crystal glazes ▪high Mg = buttery matt & opaque ▪hardens glaze ▪colors toward pastels ▪Mg + Co = purple	MAGNESIUM CARBONATE DOLOMITE TALC FRIT
STRONTIUM SrO alkaline earth flux	high	▪similar to Ca in glaze effect, but slightly more active while less fluid. ▪use .75 $SrCO_3$ to replace 1 BaO (test!) Slow to melt: soak.	STRONTIUM CARBONATE (slightly soluble)
BORON B_2O_3 viscosity agent that also functions as a flux	low-high	▪classified as a viscosity agent **but also** acts as a flux ▪produces high gloss ▪boils at high temps. ▪wide firing range ▪small amounts decrease crazing, ▪ large amounts may cause crazing ▪inhibits crystal growth & devitrification ▪thickens melted glaze, excess may cause crawling ▪may have a solvent effect and leach slip color ▪color may be opalescent, mottled w/ high B	BORAX * BORIC ACID * GERSTLEY BORATE FRIT

FRIT	Substitutes	Melting ◦F	**Comments** * (coefficient of expansion x 10^{-6})
3110 Ferro	P-IVo5 Pemco	1400	Highly alkaline. Somewhat soluble: not recommended as a body flux. As a main flux causes crazing. Coefficient of exp.10.1 *
3195 Ferro		1500	Alkaline-boron. Not as alkaline as 3110, w/more Ca, B, Al, but still tends toward alkaline color response. Coefficient of exp.6.5 *
3124 Ferro	P-311 Pemco O Hommel 90	1600	Borosilicate, high calcium, good for tableware. Coefficient of exp. 7.9*

3134 Ferro	P-54 Pemco O Hommel 14	1450	High sodium, calcium, and boron. No alumina. Coefficient of exp. 9.6*
3289 Ferro	Fusion Frit 65 GF129	1500	Barium-some sodium. Coefficient of exp. 8.2*
3819 Ferro	P-25 Pemco O Hommel 259	1400	Alka-boron. Low Ca. Coefficient of exp. 10.3*