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

**GLASS-FORMERS (RO₂)**
Silica (SiO₂) 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, NEPHELITE, CORNWALL STONE, PYROPHYLITE, AND WOLLASTONITE.

**VISCOSITY AGENTS (R₂O₃)**
Alumina (Al₂O₃) 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, NEPHELITE, CORNWALL STONE, PYROPHYLITE. **BORON** is both a flux and viscosity agent.

**FLUXES (RO, R₂O)**
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

<table>
<thead>
<tr>
<th>Flux</th>
<th>Active temp.</th>
<th>Characteristics</th>
<th>Sources (*soluble)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SODIUM Na₂O</td>
<td>low-high</td>
<td>• similar to potassium but a bit more active&lt;br&gt;• produces soft glaze surfaces that are easily abraded or attacked by acids&lt;br&gt;• high coefficient of expansion (crazes)&lt;br&gt;• brilliant color: Cu = turquoise, Mn = purple, Co = ultra-marine blue, Cr = yellow green, chartreuse w/ small amounts of Cr&lt;br&gt;• slightly more active than K or Li</td>
<td>SODA ASH *&lt;br&gt;POTASSIUM BICARBONATE *&lt;br&gt;FRIT (may be part soluble)&lt;br&gt;NEPHELITE SYENITE&lt;br&gt;CORNWALL STONE&lt;br&gt;CRYOLITE</td>
</tr>
<tr>
<td>POTASSIUM K₂O</td>
<td>low-high</td>
<td>• similar to sodium, generally, but a bit less active</td>
<td>PEARL ASH *&lt;br&gt;FRIT (may be part soluble)&lt;br&gt;NEPHELITE SYENITE&lt;br&gt;CORNWALL STONE</td>
</tr>
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| LITHIUM Li₂O 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 °F (800° 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                                                                                      |
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| BARIUM   | 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 SrCO₃ 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| 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| high         | • similar to Ca in glaze effect, but slightly more active while less fluid. • use .75 SrCO₃ to replace 1 BaO (test!) Slow to melt: soak.                                                                 | STRONTIUM CARBONATE (slightly soluble)                          |
| BORON    | 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 |

<table>
<thead>
<tr>
<th>FRIT</th>
<th>Substitutes</th>
<th>Melting °F</th>
<th>Comments * (coefficient of expansion x 10⁻⁶)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3110</td>
<td>P-IVo5 Pemco</td>
<td>1400</td>
<td>Highly alkaline. Somewhat soluble: not recommended as a body flux. As a main flux causes crazing. Coefficient of exp.10.1 *</td>
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<tr>
<td>Ferro</td>
<td></td>
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<tr>
<td>3195</td>
<td>Ferro</td>
<td>1500</td>
<td>Alkaline-boron. Not as alkaline as 3110, w/more Ca, B, Al, but still tends toward alkaline color response. Coefficient of exp.6.5 *</td>
</tr>
<tr>
<td>3124</td>
<td>P-311 Pemco</td>
<td>1600</td>
<td>Borosilicate, high calcium, good for tableware. Coefficient of exp. 7.9*</td>
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<tr>
<td>Ferro</td>
<td>O Hommel 90</td>
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<tr>
<td></td>
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<tr>
<td>3134</td>
<td>P-54 Pemco O Hommel 14</td>
<td>1450</td>
<td>High sodium, calcium, and boron. No alumina. Coefficient of exp. 9.6*</td>
</tr>
<tr>
<td>3289</td>
<td>Fusion Frit 65 GF129</td>
<td>1500</td>
<td>Barium-some sodium. Coefficient of exp. 8.2*</td>
</tr>
<tr>
<td>3819</td>
<td>P-25 Pemco O Hommel 259</td>
<td>1400</td>
<td>Alka-boron. Low Ca. Coefficient of exp. 10.3*</td>
</tr>
</tbody>
</table>