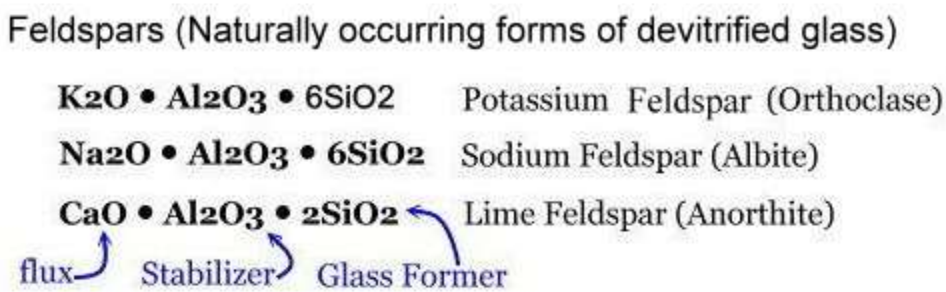
FELDSPAR INFO – Collected from a variety of sources.

Feldspar is by far the most abundant group of minerals in the earth's crust, forming about 60% of terrestrial rocks. Most deposits offer sodium feldspar as well as potassium feldspar and mixed feldspars. Feldspars are primarily used in industrial applications for their alumina and alkali content.

Ceramics: In the manufacture of ceramics, feldspar is the second most important ingredient after clay. Feldspar does not have a strict melting point, since it melts gradually over a range of temperatures. This greatly facilitates the melting of quartz and clays and, through appropriate mixing, allows modulations of this important step of ceramic making. Feldspars are used as fluxing agents to form a glassy phase at low temperatures and as a source of alkalies and alumina in glazes. They improve the strength, toughness, and durability of the ceramic body, and cement the crystalline phase of other ingredients, softening, melting and wetting other batch constituents.



Feldspars melt at about 1150 degrees C. The **feldspathic glass** they produce surrounds the refractory clay particles and fills up the pores between them. Due to the free fluxes they contain, feldspathic glasses will also bind to the surfaces of the refractory particles thus helping to bind the ceramic body together. The more feldspathic glass a ceramic body contains, the denser the fired body will be.

Each of the three components of feldspar is discussed below.

- **Fluxes** --The **Na2O**, **K2O** and **CaO** in the above formulas are called **alkaline metal oxides** because they are strong bases when added to water. These oxides are used as **fluxes**. Fluxes have very active molecular structures at high temperature, and they attach to and combine with the surface molecular structure of otherwise hard crystalline materials, causing the surface molecules in the crystals to "dissolve". This exposes deeper layers of the crystal to the dissolving action of other flux molecules and so on until the entire crystal melts away. In other words, fluxes cause crystalline structures to melt at lower temperatures than would otherwise be possible, a bit like water melts a cube of sugar at room temperature. Without fluxes present, none of the other constituents in the ceramic body would be able to melt at normally attainable temperatures, and the fabrication of pottery would have been beyond the reach of prehistoric peoples.

- **Aluminum oxide** -- (**Al2O3**).**(Stabilizer)** Aluminum oxide exists in two separate forms within clay and porcelain bodies**.**
  - When chemically combined in molecular form with the other constituents of feldspars (see formulas above), aluminum oxide acts as a stabilizer, and is a part of the glass melt. Aluminum atoms can bond with silicon via a shared oxygen atom and can thus be an integral part of the amorphous silicon matrix. In this form, it does NOT affect the transparency of the glass.
  - However, aluminum oxide is also added to clays as a separate constituent in the form of kaolinite. Because of the large amount of flux contained in the feldspar, some of the kaolinite also melts into a glass, like the feldspar itself. But the byproduct left over when the kaolinite

melts is a precipitate of pure crystalline aluminum oxide called **alumina**. The alumina crystals remain unmelted (ie. they are refractory particles) and scattered throughout the glass melt, and in this form, aluminum oxide causes the glass to become cloudy or opaque.

- **Silica –(Glass Former)** Silica is silicon dioxide, the **SiO2** portion of the feldspar formulas shown above. Like alumina, silica also exists in two entirely separate forms within clay and porcelain bodies.
  - When chemically combined with flux and aluminum oxide, as it is in feldspar, silica exists as a molecular component in the amorphous melted **glass** gel.
  - Silica also exists as as unmelted crystalline particles of **quartz** scattered throughout the glass melt.This form is part of the refractory substructure which supports clay and porcelain bodies.

Compositions

This group of minerals consists of framework tectosilicates. Compositions of major elements in common feldspars can be expressed in terms of three endmembers:

- Potassium-Feldspar (K-spar) endmember $KAlSi_3O_8$
- Albite endmember $NaAlSi_3O_8$[1]
- Anorthite endmember $CaAl_2Si_2O_8$

Potash Feldspars

The presence of potash feldspar in a glaze or clay body has a more refractory effect on the ceramic surface compared to equivalent amounts of soda feldspar. Although potash feldspar actually begins its melt at a lower temperature than soda feldspar, once the melt begins, the formation of leucite crystals causes a slower and more viscous flow.

Soda Feldspars

Kona F-4 and NC-4 feldspars contain a fair amount of potassium oxide, and their total sodium content is not as high as the total content of potassium in potash feldspars. These feldspars are hybrids that incorporate some qualities of both potash and soda feldspars. This is especially evident when they're compared to stronger sodium materials, such as nepheline syenite. Hence, it's often possible to substitute some soda feldspars for potash feldspars without causing a dramatic surface change.

Nepheline Syenite

Nepheline syenite is a low-silica, high-soda, high-alumina mineral referred to as a feldspathic rock. The fluxing power and shrinkage rate of nepheline syenite depends on the grade number. The finest grades (A400 and 700) have the greatest melting power and shrinkage rate and are used in electrical porcelain and by manufacturers of ceramic wares. Grade A270 has a medium melting and shrinkage rate and is the most commonly used form of nepheline syenite in ceramic studios and schools. Grades A40-A200 (used by glass manufacturers) are the coarsest grades and produce the lowest melting and shrinkage rates.

Cornwall stone

Cornwall stone, also a feldspathic rock, contains more silica and less melter oxides than do the feldspars. Since silica has a high melting point, Cornwall stone has a higher melting temperature than the feldspars and appears stiffer and less melted when fired alone to stoneware temperatures. This is especially apparent at the lower stoneware temperatures. Even the potash feldspars show more fusion at the cone 5-6 oxidation firing temperatures than does Cornwall stone, so this would not be a first choice as a glaze core at these firing temperatures unless a stiffer surface is desired.

Substituting

When recipes call for an uncommon or extinct feldspar, substitutions are possible, but you may need to make adjustments to other components in the glaze, such as clay, silica, and/or one of the fluxes. In many tests, substituting a soda feldspar for the potash feldspar caused little change in the glaze surface. Of all the glaze cores, potash and soda feldspars produced the least difference when substituted for each other; and can often be interchanged without causing drastic changes in the glaze surface.

Potash feldspars can usually substitute for each other in most glaze formulas without producing major changes in surface, provided the silica and alumina content are not too different. The difference in the feldspars' silica content can be compensated for by adding or removing silica from the glaze formula. In any case, before making large-scale substitutions, compare the oxide structure of both feldspars and recompute the percentage oxide analysis of the glaze with the substituted feldspar.

Substitution of soda spar for potash spar can lower vitrification by 100 degrees.

KINGMAN FELDSPAR - Potash spar no longer mined. Substitute CUSTER or G-200.

KONA F-4 FELDSPAR - $Na_2O.Al_2O_3.6SiO_2$ - a common soda feldspar - powerful HT alkaline flux.

CORNWALL STONE; CORNISH STONE - $K_2O/Na_2O/CaO.Al_2O_3.10SiO_2$ - HT feldspathic alkaline flux containing calcium and potassium, but more refractory than potash feldspars. Substitution: eight parts potash feldspar, two parts silica, one part kaolin.

CUSTER FELDSPAR - $K_2O.Al_2O_3.6SiO_2$ - a common potash feldspar - HT alkaline flux. Close match to G-200.

GERSTLEY BORATE; COLEMANITE; CALCIUM BORATE - $2CaO.3B_2O_3$ - major LT alkaline flux - often gives slight opalescence in glaze - for greater transparency and long-term stability substitute Ferro 3134 or other Gerstley borate substitute.

NEPHELINE SYENITE - $K_2O.3Na_2O.4Al_2O_3.9SiO_2$ - a common feldspathic flux, high in both soda and potash, used in claybodies and glazes. Less silica than soda feldspars, and therefore more powerful. Increases firing range of low-fire and midrange glazes.

SODA FELDSPAR - $Na_2O.Al_2O_3.6SiO_2$ - feldspars contributing sodium (and potassium), primarily as a HT flux - includes KONA F-4, NC-4 and NEPHYLINE SYENITE.

SPODUMENE - $Li_2O.Al_2O_3.4SiO_2$ - lithium feldspar - powerful HT alkaline flux – promotes copper blues - good for thermal-shock bodies and matching glazes.

Substituting **nepheline syenite** for a feldspar or Cornwall stone appreciably lowers the firing temperature of the glaze or clay body. A comparison of the quantities of potash feldspar and nepheline syenite necessary to produce an equivalent melt shows that approximately 25% more potash feldspar is required to produce the same fluxing activity obtained with nepheline syenite. Despite its increased melting action, the lower silica and higher alumina content of nepheline syenite can cause a gloss surface to become more matt.

When using **Cornwall stone** as a substitute for a soda or potash feldspar in a glaze formula, it may drastically alter the glaze surface. It brings an increased amount of silica and less melter oxides to the glaze combination. This substitution can raise the firing temperatures of the glaze, with the result that a formerly shiny and glassy surface may appear more opaque and more matt.
Although substituting Cornwall stone for a feldspar lowers the total melter content of the glaze formula, the large amount of auxiliary melters already present in the glaze may suffice to melt the additional silica brought in by the Cornwall stone. The glaze's color may change if Cornwall stone is substituted for a feldspar; it

contains more iron oxide and other impurities than do the feldspars. These impurities, together with the increased silica content, can produce distinctive color differences, especially in high iron glazes.

Comparison between G200 & Custer Feldspar

You can switch to Custer Feldspar for your glaze formulations. The table below shows the relative chemical composition of these two Potash feldspars. As you can see they are very similar.

	SiO2	Al2O3	Fe2O3	CaO	Na2O	K2O
G-200	66.40	18.96	.08	.64	2.98	10.54
Custer	68.50	17.50	.08	.30	3.00	10.40