

# Virginia Kyanite and Mullite

The Mineral of Choice for Controlling  
the Shrinkage of High Alumina  
Monolithic Refractories and provide  
high hot strength, volume stability and  
high creep resistance

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# Materials Used in High Alumina Monolithic Refractories

## Active Ingredients\*

- 1) Bonding Agents
- 2) Plasticizers
- 3) Shrinkage Control Aids
- 4) Nucleators & Catalysts
- 5) Flow enhancers

*\* Active Ingredients are "additives" such as Kyanite, Clays, Calcium Aluminates, etc.*

## Inert Ingredients

Calcined Clay  
Andalusite & Sillimanite  
Calcined Kyanite  
Calcined Bauxite  
Corundum (BFA, WFA)



Kyanite is an additive used in monolithic mixes to regulate volume change, while enhancing refractoriness. But it has many other desirable & beneficial attributes

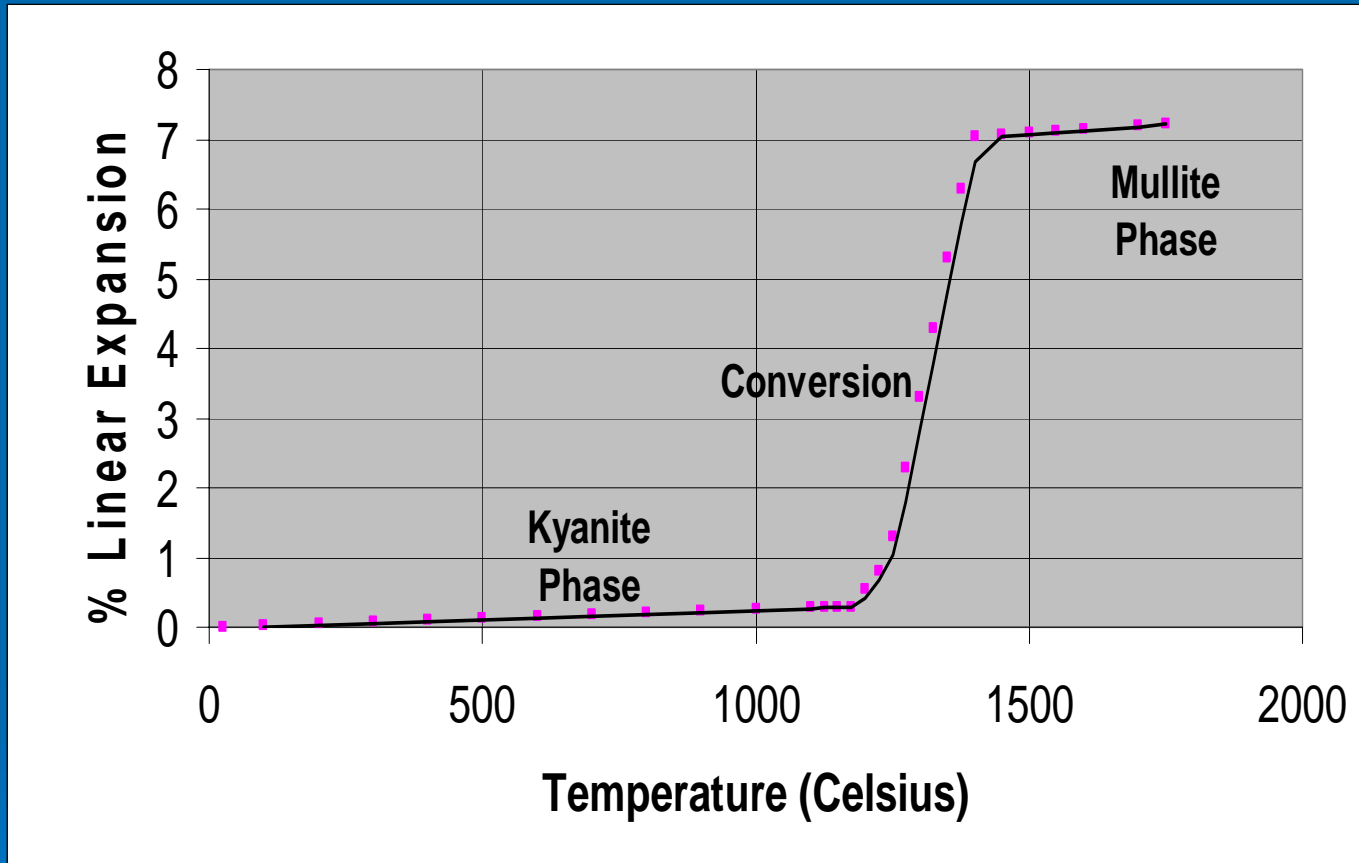
# The Properties of Kyanite

- Large “Irreversible” Volume Expansion (upon conversion)\*
- Very Low “Reversible” Thermal Expansion\*
- Unique “Lath-Like” Particle Shape\*
- Forms Mullite at a Low Decomposition Temperature\*
- Alumina Content & Purity Promote High Refractoriness  
(56-60%  $Al_2O_3$ , very low iron and virtually no alkalis)
- High Particle Packing Density



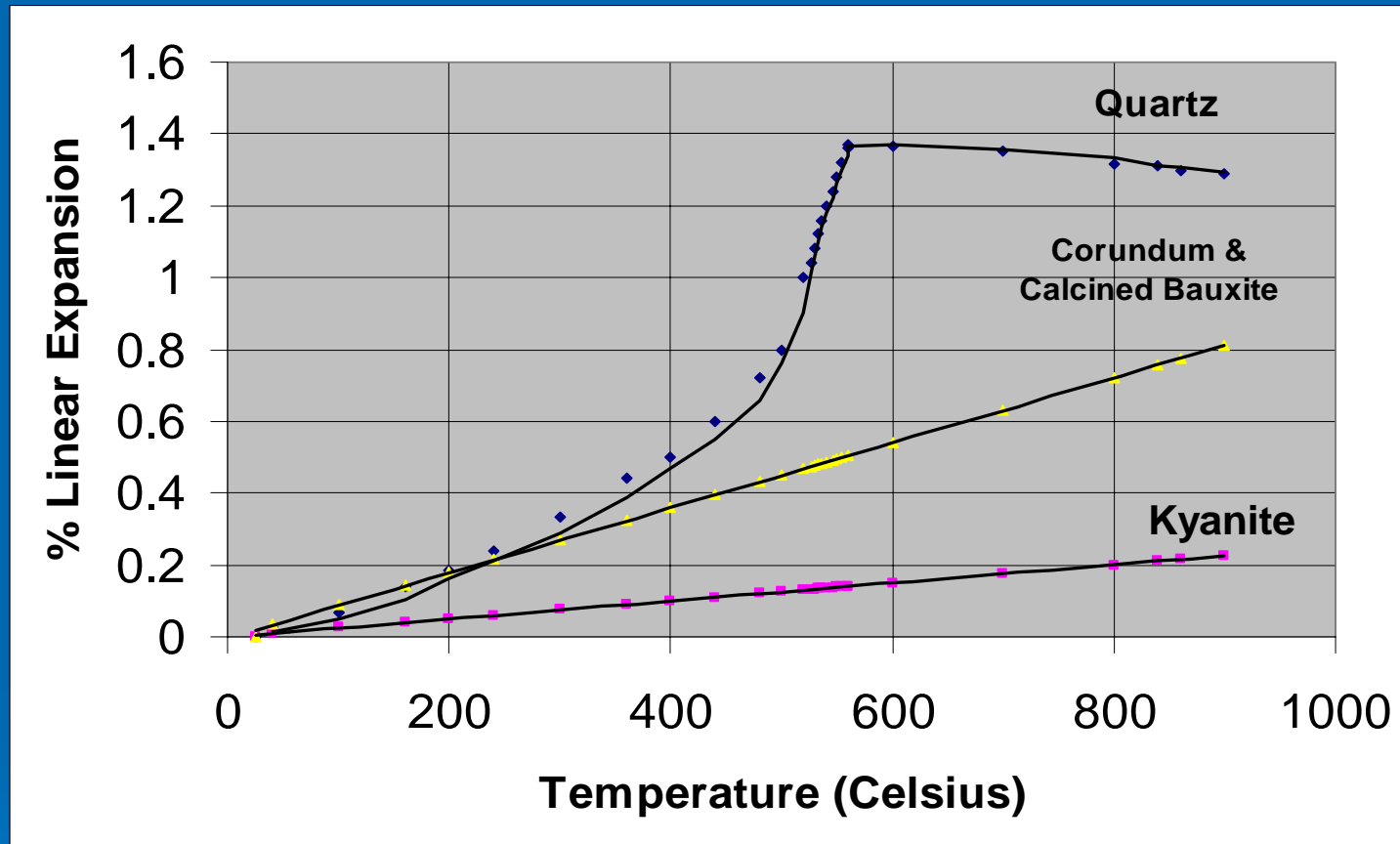
Kyanite is a raw material additive that has wide variety of beneficial properties which can be utilized by refractory engineers. Some of these properties\* are unique

# Thermal Expansion & Conversion of Kyanite



Kyanite demonstrates unique expansion characteristics when heated to (and through) its decomposition temperature

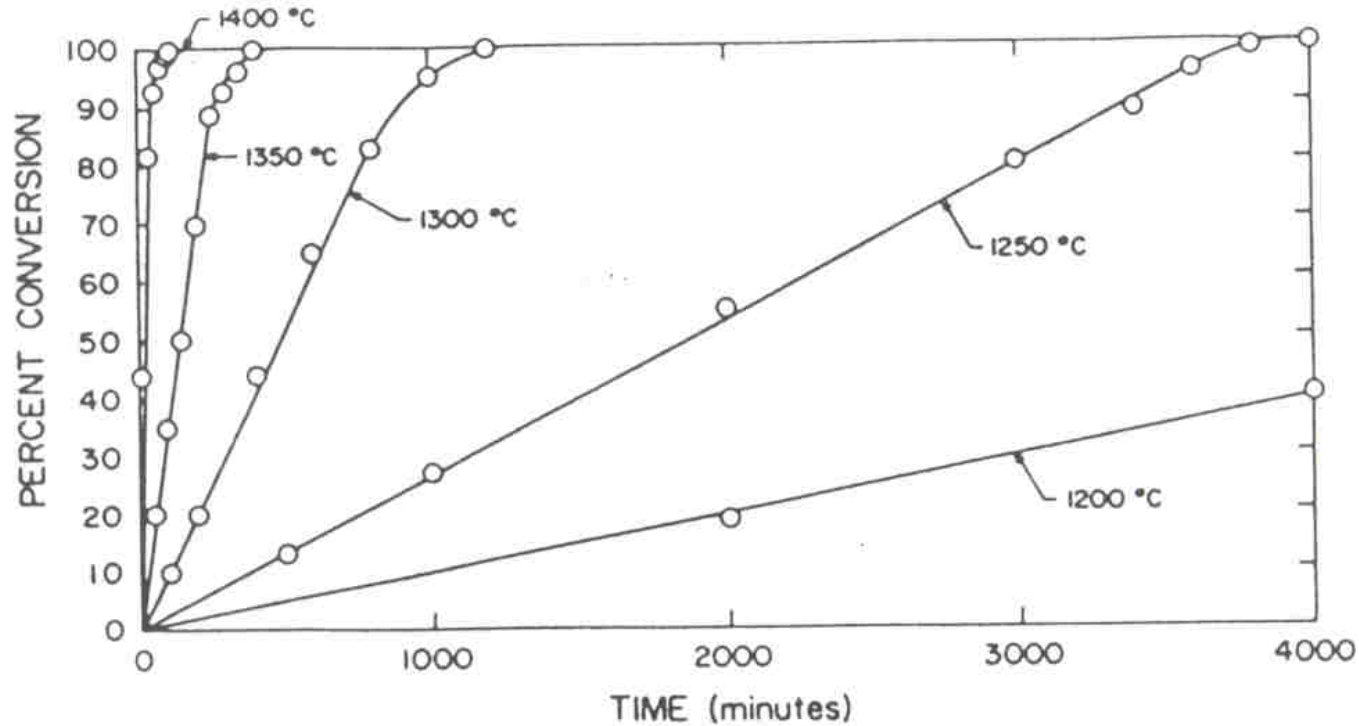
# The Thermal Expansion of Kyanite



Kyanite has a low “reversible” coefficient of thermal expansion – at temps below 1,000°C.

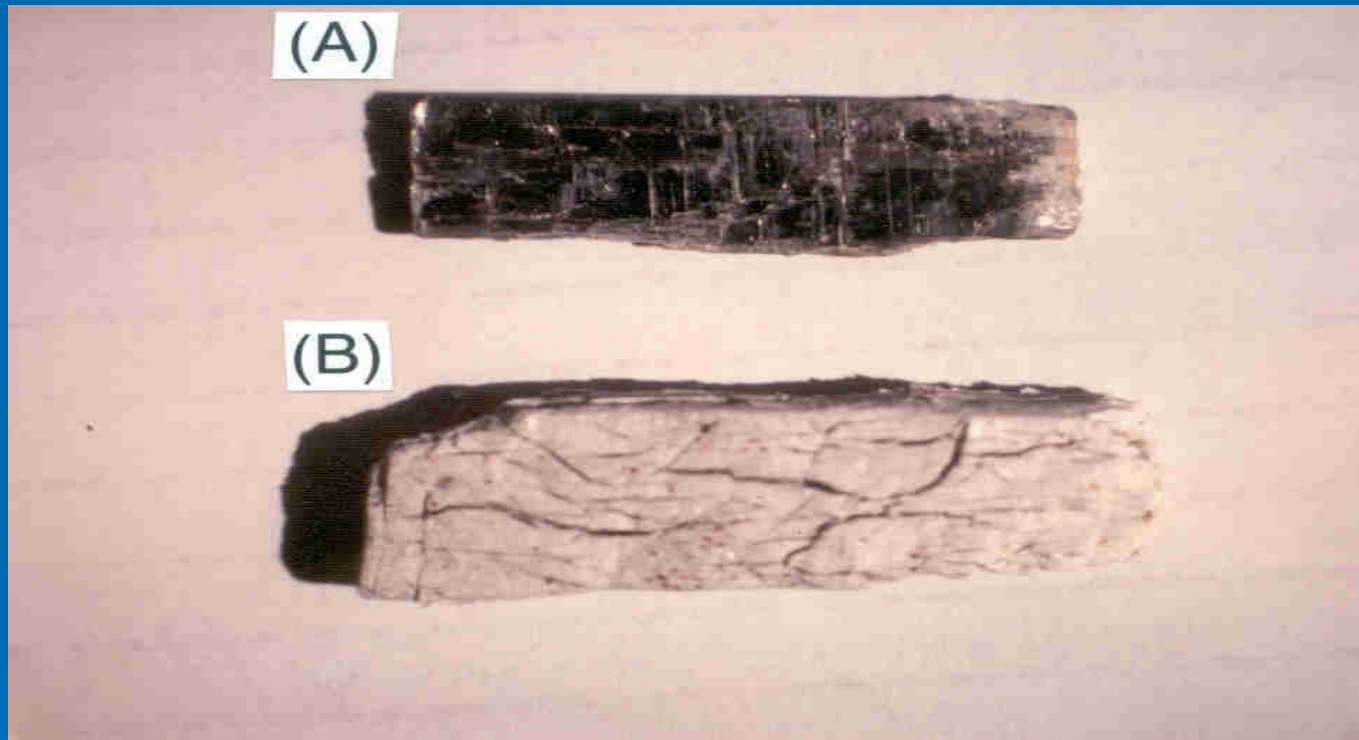
This is a very useful characteristic for lower temp refractory applications

# Kyanite's Conversion to Mullite



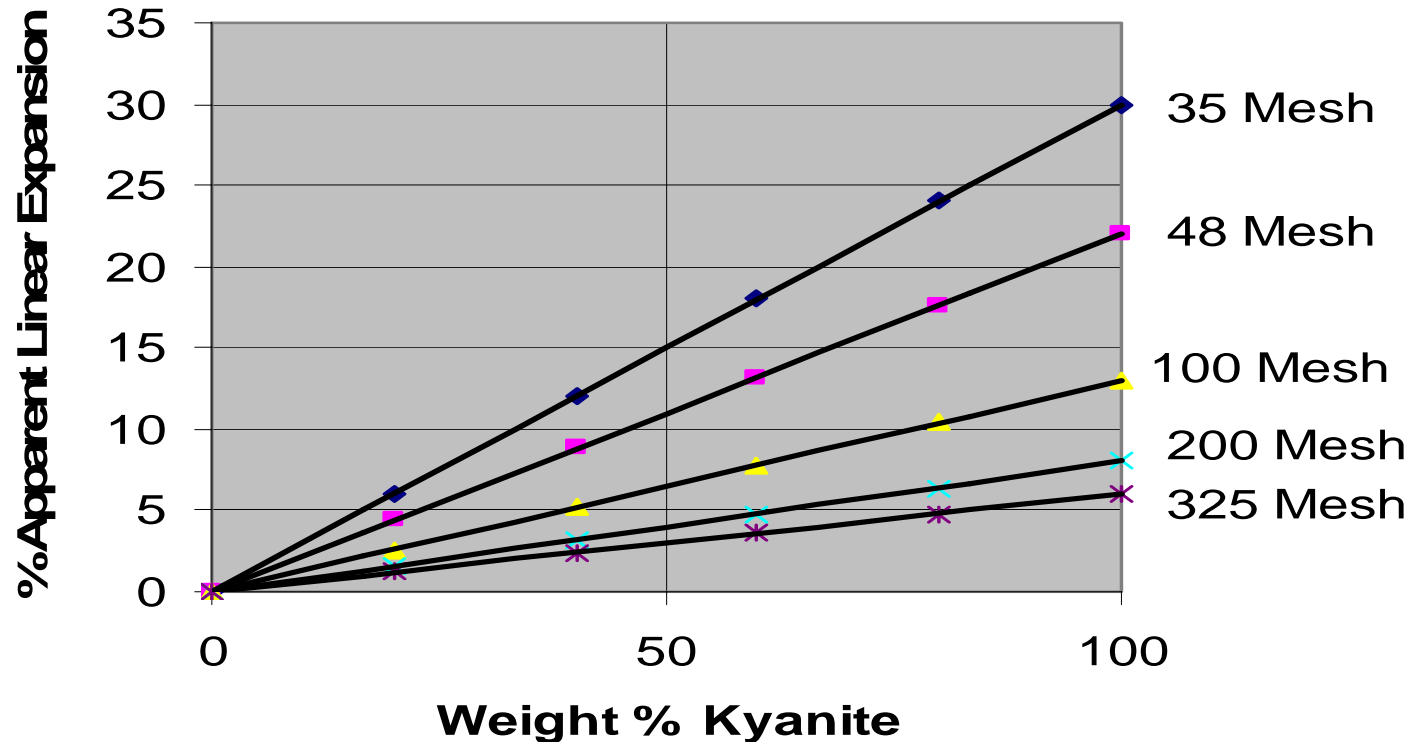
The Mullitization of kyanite begins at about 1,250°C, and is completed virtually instantaneously at 1,450°C. (much faster & at a much lower temp than either Andalusite or Sillimanite)

# The Irreversible Expansion of a Single Kyanite Crystal



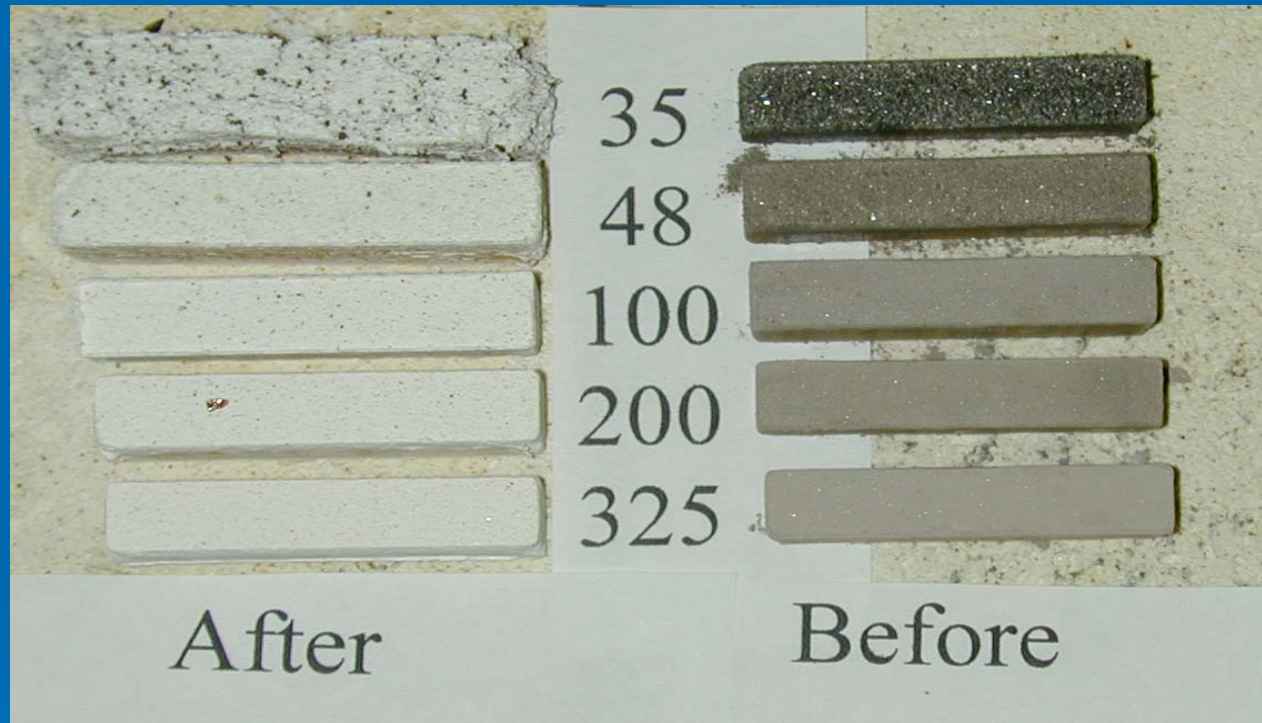
A single Kyanite crystal almost doubles in volume as it is heated to 1450 c and converts to mullite

# Effect of particle size on Expansion



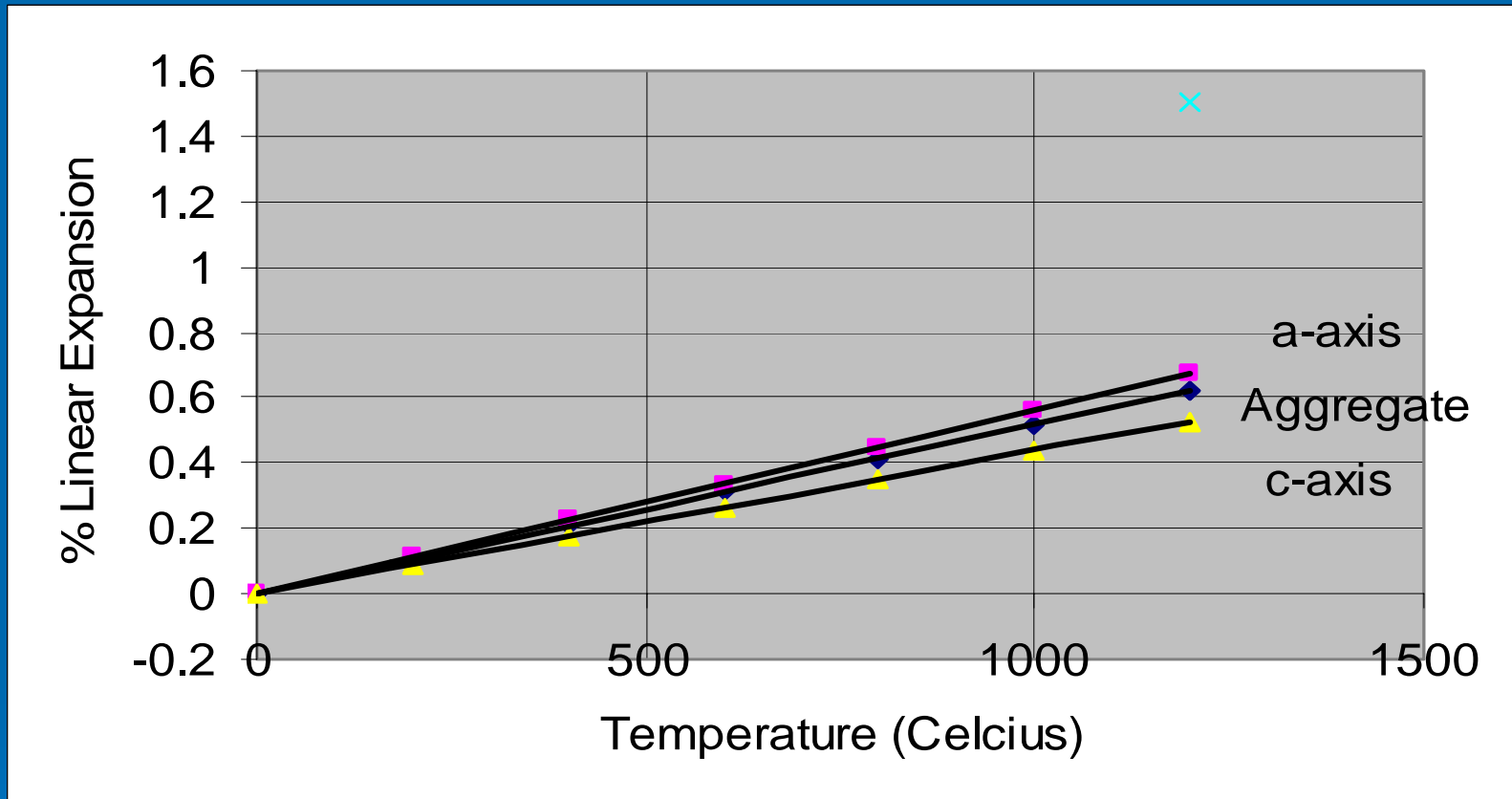
Apparent volume expansion of 35 mesh Kyanite is much more than the 325m Kyanite. This is simply because of the particle packing effect. Specific gravity of Kyanite is 3.55 gms/cc where as the specific gravity of Mullite is 3.0 gms/cc

# The Effects of particle size on the Irreversible Expansion of Kyanite



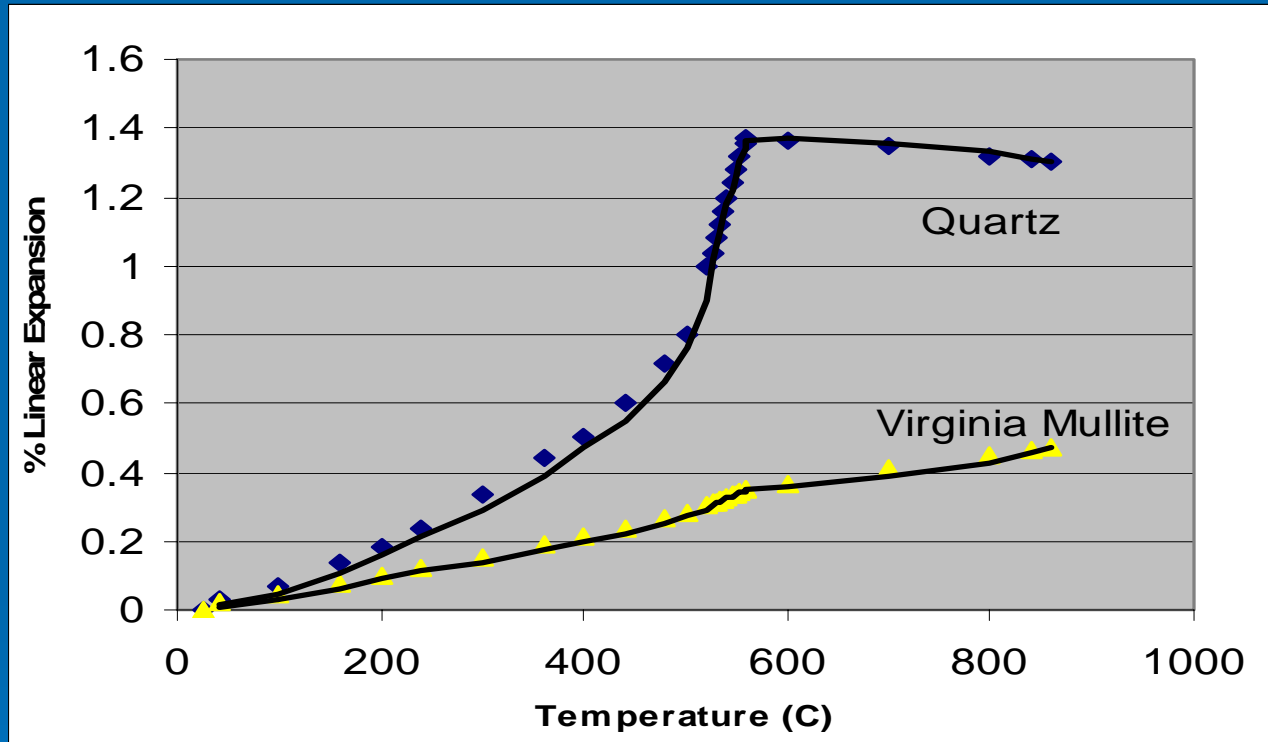
The apparent volume expansion of finer Kyanite is lower because the Volume expansion of fines take up the void space. For this reason Kyanite fines are an Excellent additive for high alumina bricks to help reduce porosity and improve creep Resistance of bricks.

# Thermal Expansion of Virginia Mullite



Mullite has low anisotropy – which means that its expansion along the different axial dimensions is almost the same. This contributes to high thermal shock resistance.

# Thermal Expansion of Virginia Mullite



The thermal expansion of Virginia Mullite contains a small inflection due to the presence of small amounts of quartz in the commercial concentrate

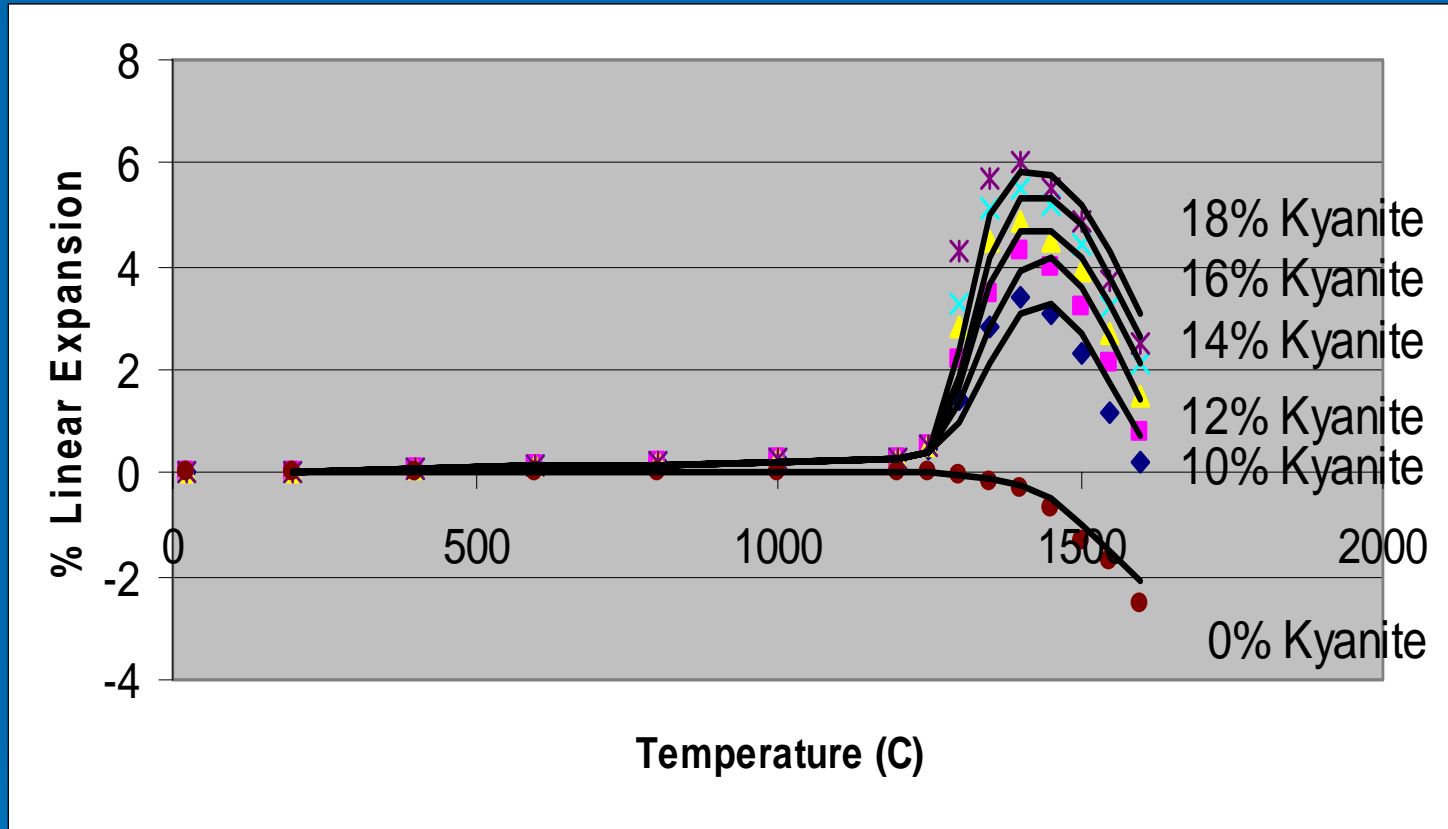
# Reasons why Kyanite is used in Monolithics

- 1) Large & Predictable “Irreversible” Thermal Expansion
  - Tightens structure of monolithics
  - Helps in reducing porosity of monolithics
  - Expansion of Kyanite offsets shrinkages from other ingredients
  - Helps in maintaining volume stability
- 2) Alumina Content & Purity
  - Provides good “refractoriness”
  - Converts to Mullite upon heating at a fairly low temperature
  - Promotes the formation of secondary mullite
  - Contributes to improved Hot MOR and Creep Resistance
- 3) Unique Lath-like Particle Shape
  - Enhances Green Strength
- 4) Low “Reversible” Thermal Expansion
  - Promotes good thermal shock resistance: for kyanite below 1,200°C, and for Mullite at any temperature

# Uses of Kyanite in Refractories

- 1) All low, ultra low cement, no cement castables, self flow, Shotcretes castables
- 2) Gunning mixes, ramming mixes
- 3) Dry Vibratable,
- 4) Plastics
- 5) Mortars and patching materials
- 6) Steel and iron ladle lances
- 7) Variety of pre cast shapes
- 8) Bricks and other shaped Refractories to reduce porosity and increase creep resistance
- 9) High temperature insulating firebricks

# Effects of Kyanite in a Refractory Body



The typical volume change in the size of the final refractory body is controllable by means of the judicious addition of specific amounts and size of kyanite

# Alumina Content & Purity

A) Commercially available kyanite concentrate is very pure and has an alumina content of 57% (*and about 0.6% total iron, and virtually no alkalis*)

- Kyanite is an excellent refractory in and of itself
- Absence of any glass phase during transformation helps limit liquid formation at high temperatures
- Contributes to improved Hot MOR
- Raises Creep Resistance

B) As a bonus, kyanite acts as a nucleating agent for the development of secondary mullite.

- A function of particle size, decomposition temp & activation energy
- Significantly improves hot strength & high temp mechanical properties
- Enhances thermal shock resistance

# Properties of Virginia Mullite

- 1) Virginia Mullite has the least amount of impurities than most commercially available Mullite aggregates.
- 2) Has high Refractoriness (37+ PCE)
- 3) Is volume stable at very high temperatures
- 4) Has excellent thermal and physical properties
- 5) Has low coefficient of thermal expansion ( $5.3 \times 10^{-6}$ )
- 6) Is an excellent thermal and electrical insulator
- 7) Imparts High hot strength and outstanding hot load-bearing properties
- 8) Is resistance to acidic corrosion



**Mullite is a critical ingredient in high temp, high strength, thermal shock resistant & chemically stable refractory products**