Institute of Refractories Engineers

WEAR OF ALUMINA REFRACTORIES

IRE Training Day
31 October 2013

Sheffield

Sam Franklin

Contents

Wear of Refractories

Thermal

- Temperature Gradient
- Temperature cycles

Mechanical

- Abrasion
- Vibration
- Stress

Chemical

- Corrosion from hydrogen
- Reducing Atmosphere
- Gases

Wear Zones

- Different Conditions in different zones
  - Impact zones
  - High temp zones
  - Chemical attack zones
- Optimise refractories to the conditions

- What if operation 'shifts the zones'?

Thermal Wear

- Excess Temperature
  - Melting
  - Softening
- Thermal Shock
  - Rapid Heating and Cooling

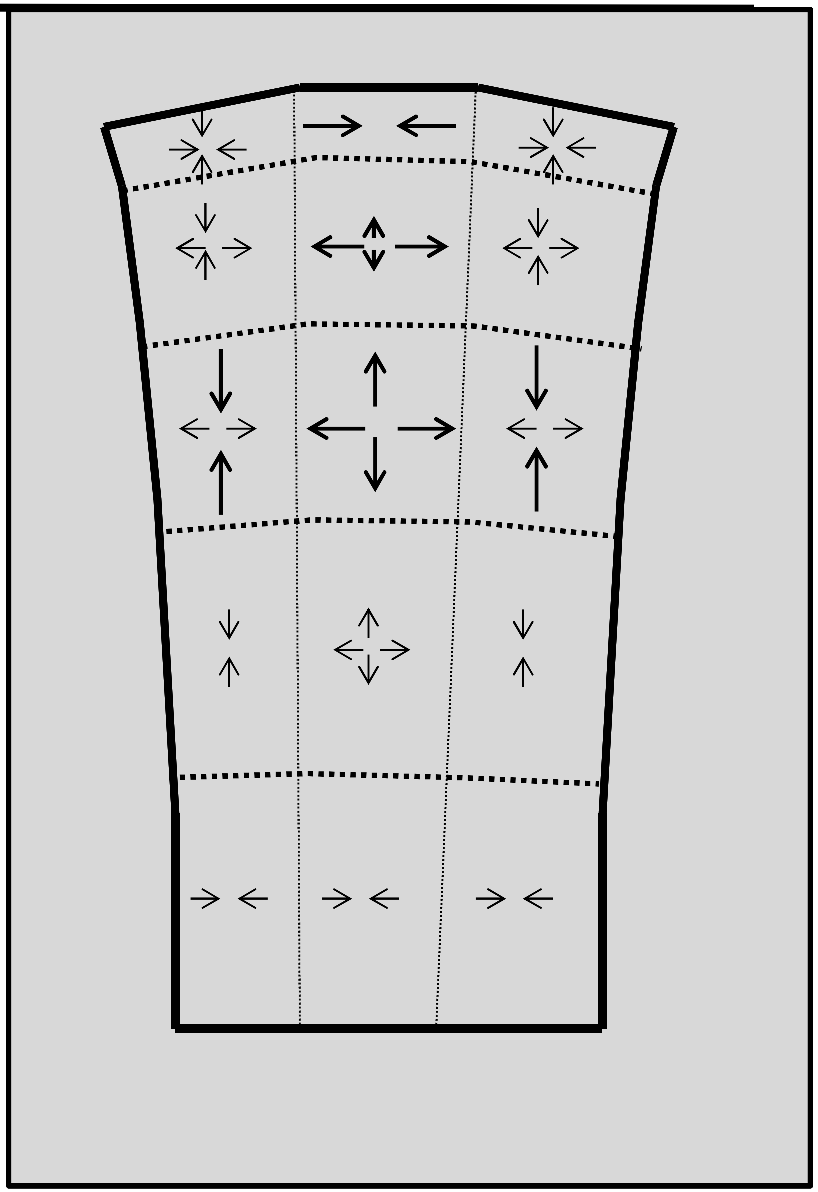
Excess Temperature

- Melting
- Softening
- Slumping
- Shrinkage

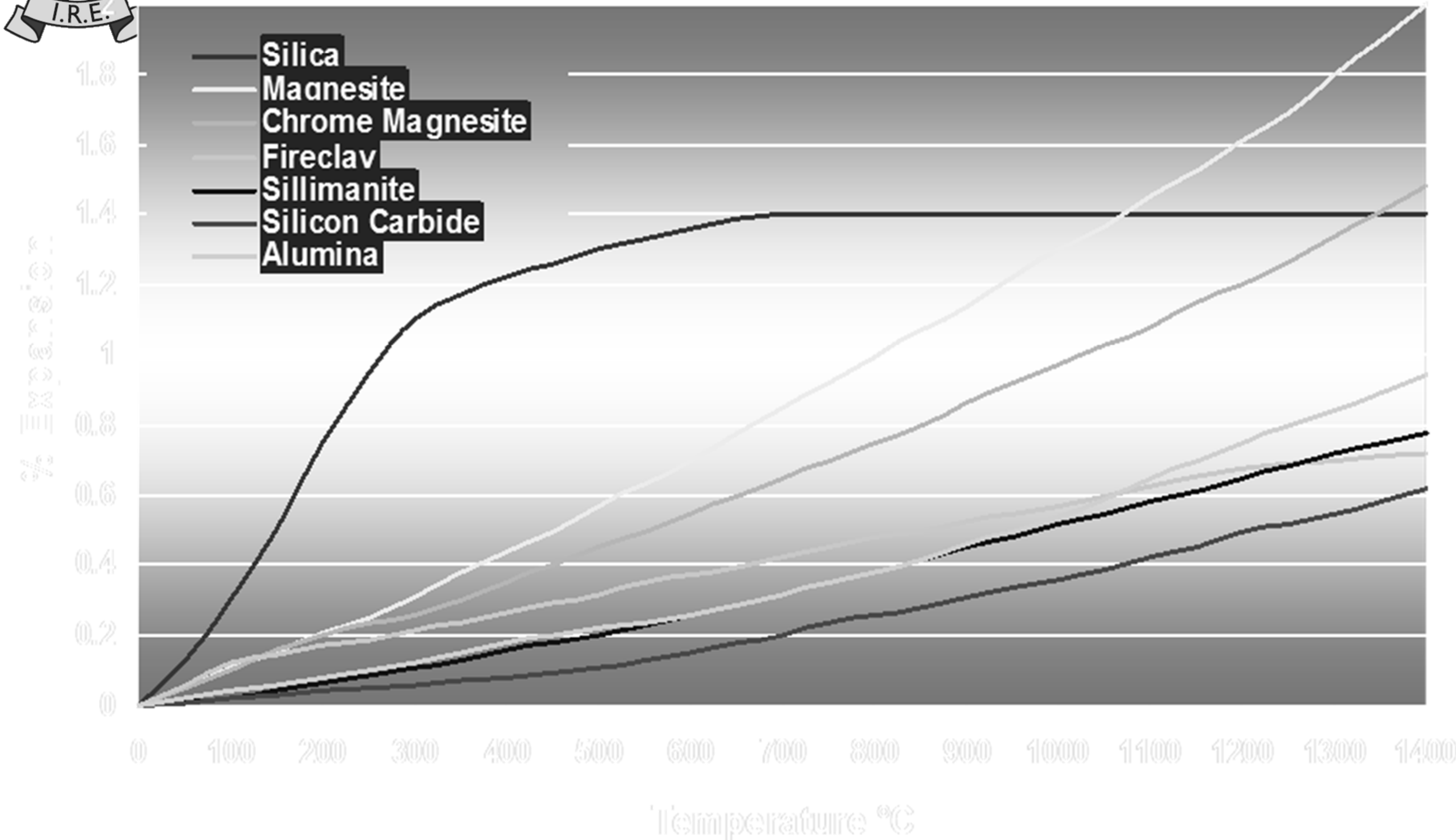
- Flame impingement

Thermal Shock

- Consider a brick heated on one face.
- The heated face 'wants' to expand
  - It is restrained by the colder part
  - There are stresses in the brick



Thermal Shock – Effect of Expansion



Thermal Shock

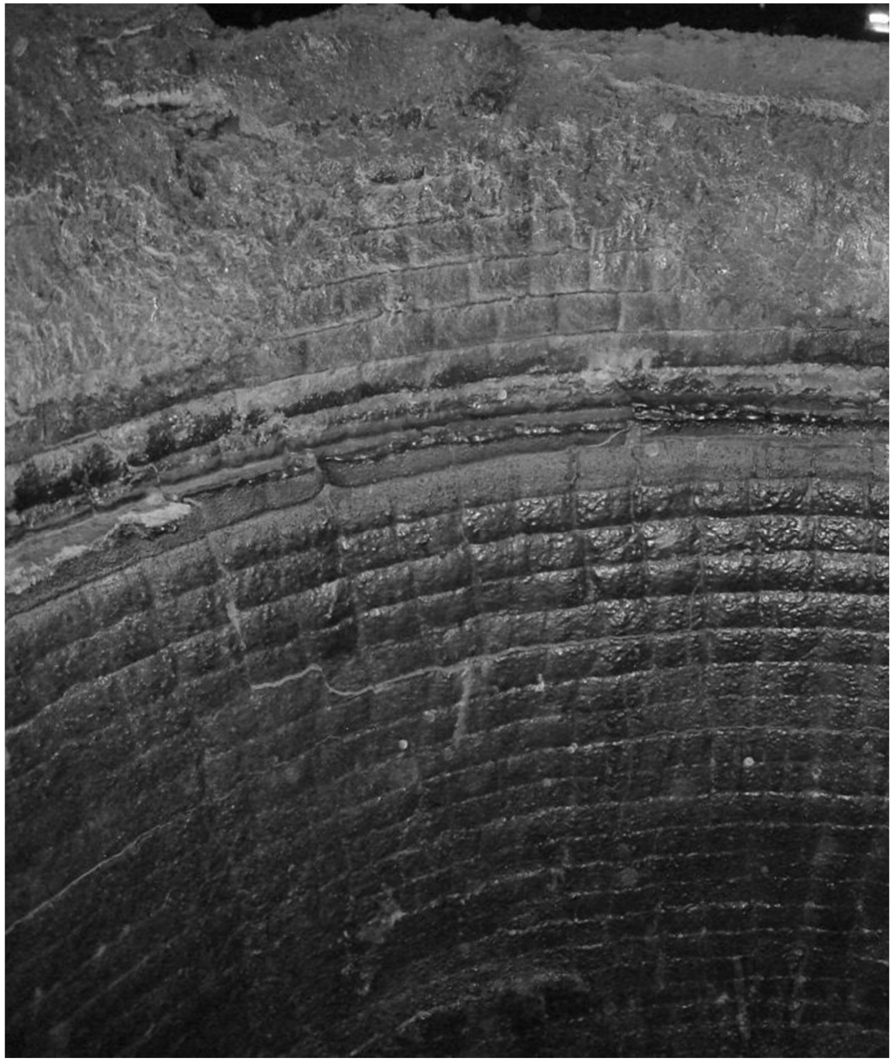
- Rapid heating or cooling leads to high temperature gradients
- Thermal expansion creates internal stresses
- Cracking if these stresses exceed strength

Chemical Wear

- Slag Attack
- Alkali Attack
- CO, H_2, Cl_2
- Acid

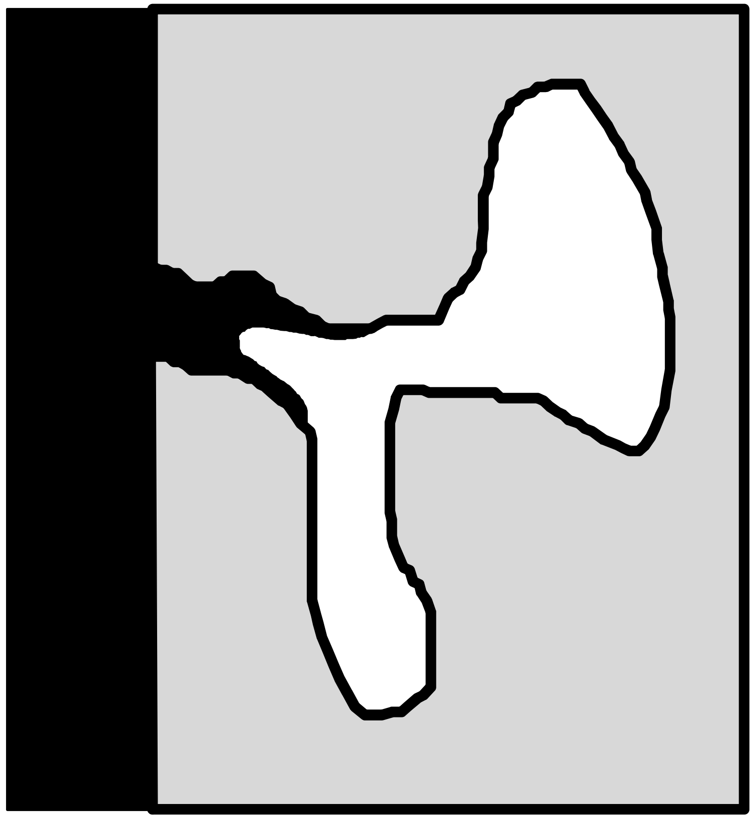
Slag Attack

- Slag dissolves oxide refractories
- Slag wets oxide refractories and penetrates the material
- Slag affected zone has different expansion and thermal properties and may crack away



Porosity and Slag Attack

- Refractories contain voids
  - Spaces between grains
- Oxide slags are chemically similar to refractories
- Liquid slag ‘wets’ surface and soaks into pores
- Attack from inside not just surface



Slag Chemistry

- Acid Slags have high SiO_2 content
- Basic Slags have high CaO content

- Basic slags disolve silica containing refractories
- Acid slags disolve basic refractories

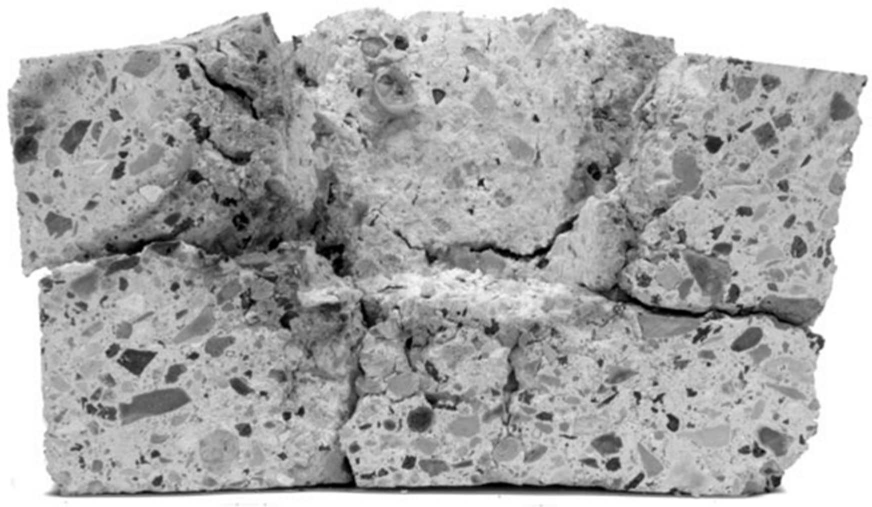
- What about alumina?

Slag Temperature

- Higher temperature
  - Makes slag more fluid
  - Greater flow rates
  - Slag penetrates further into brick
  - Slag has greater capacity to dissolve refractory

Alkali Attack

- Chemical attack by Sodium and Potassium Compounds
  - K_2O, Na_2O

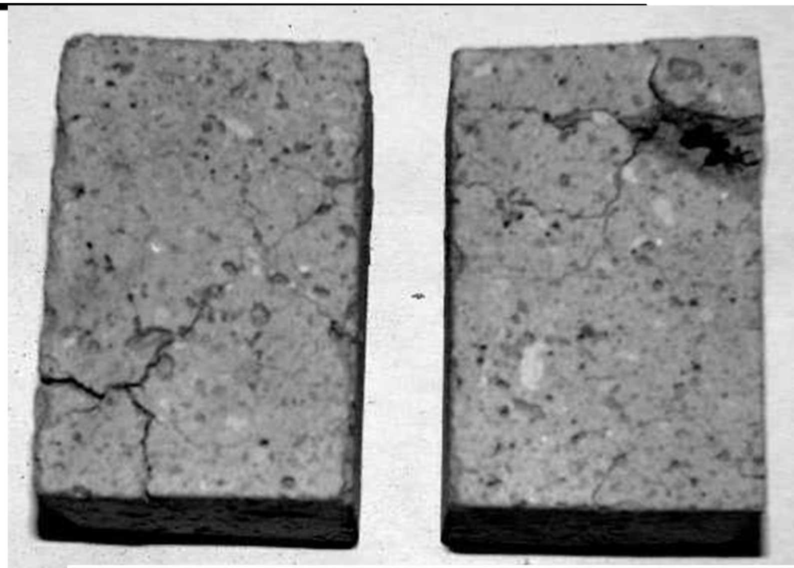


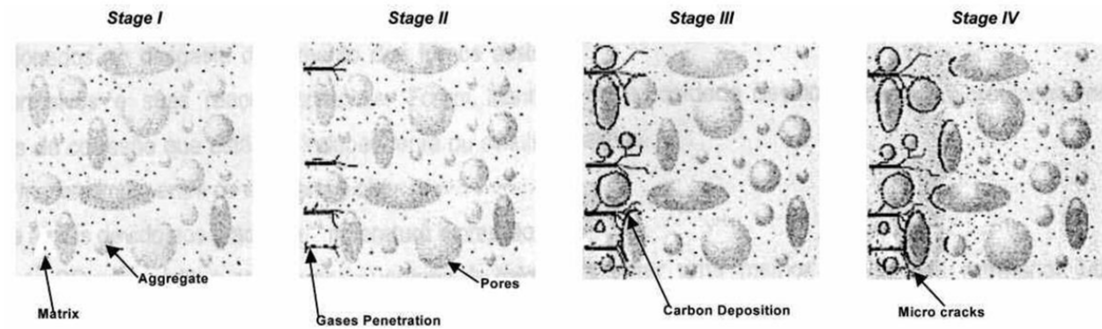
CO Attack

- Chemical Reaction

  $$2CO \rightarrow C + CO_2$$

- Deposition onto impurities, especially iron and nickel
- Deposits solid carbon
- Can disrupt parent material causing cracks and crumbling
- Only occurs in temp range 300-800°C





Hydrogen Attack

- Chemical attack
  - Reaction with silica component of refractory

    $SiO_2 + H_2 \rightarrow SiO\ (gas) + H_2O$
  - Can destroy refractory leaving a weak powder behind
  - Occurs above ~800°C

  - Affects silica containing materials

Mechanical Wear

- Impact
- Abrasion
- Erosion
- Anchor Failure

Impact Damage

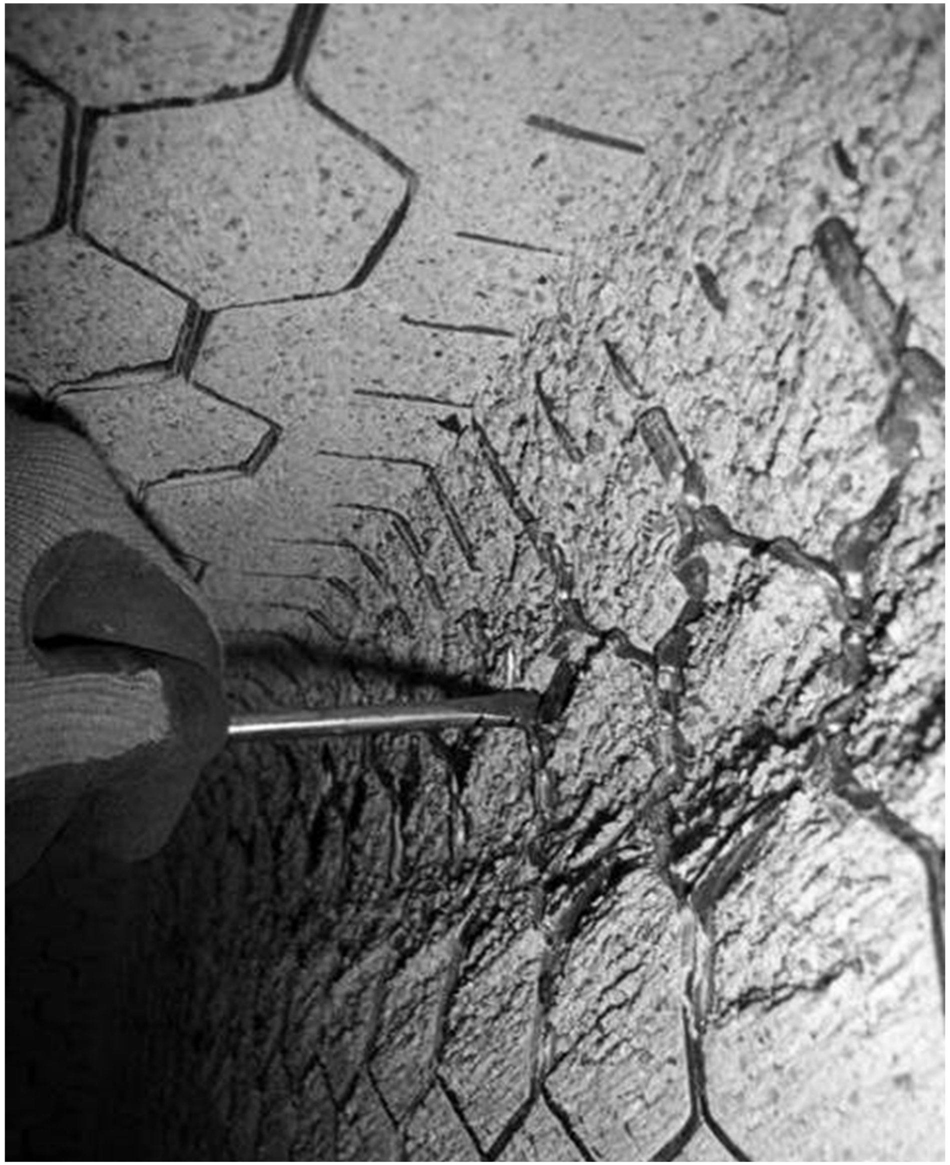
- Impact from Maintenance Equipment
- Inpact from Charging

Erosion

- Liquid Flow
- Slurry flow

Abrasion

- Solid-Solid Contact
- Dust Laden Gases



Build Up

- ‘Sticky’ materials can adhere to refractory walls
  - Slags or glass which solidify on cooler areas
  - Deposits such as carbon
- Can hold other materials such as solids to build up

- Weight of build up can
  - damage anchors
  - pull refractory off anchors
- Inpact when build up falls
- Choking of process
  - Move reaction zones

Vibration

- Lining moving out of place
- Cracking, crumbling
- Crushing of insulation

Thermomechanical Wear

- Pinch Spalling
- Restrained Expansion
- Creep

Pinch Spalling

- Excess Hoop stress, especially at hot face
- Cracking, esp near joints
- Uneven shapes and poor control of courses cause point contact
- Occurs soon after start up or if design temperature exceeded

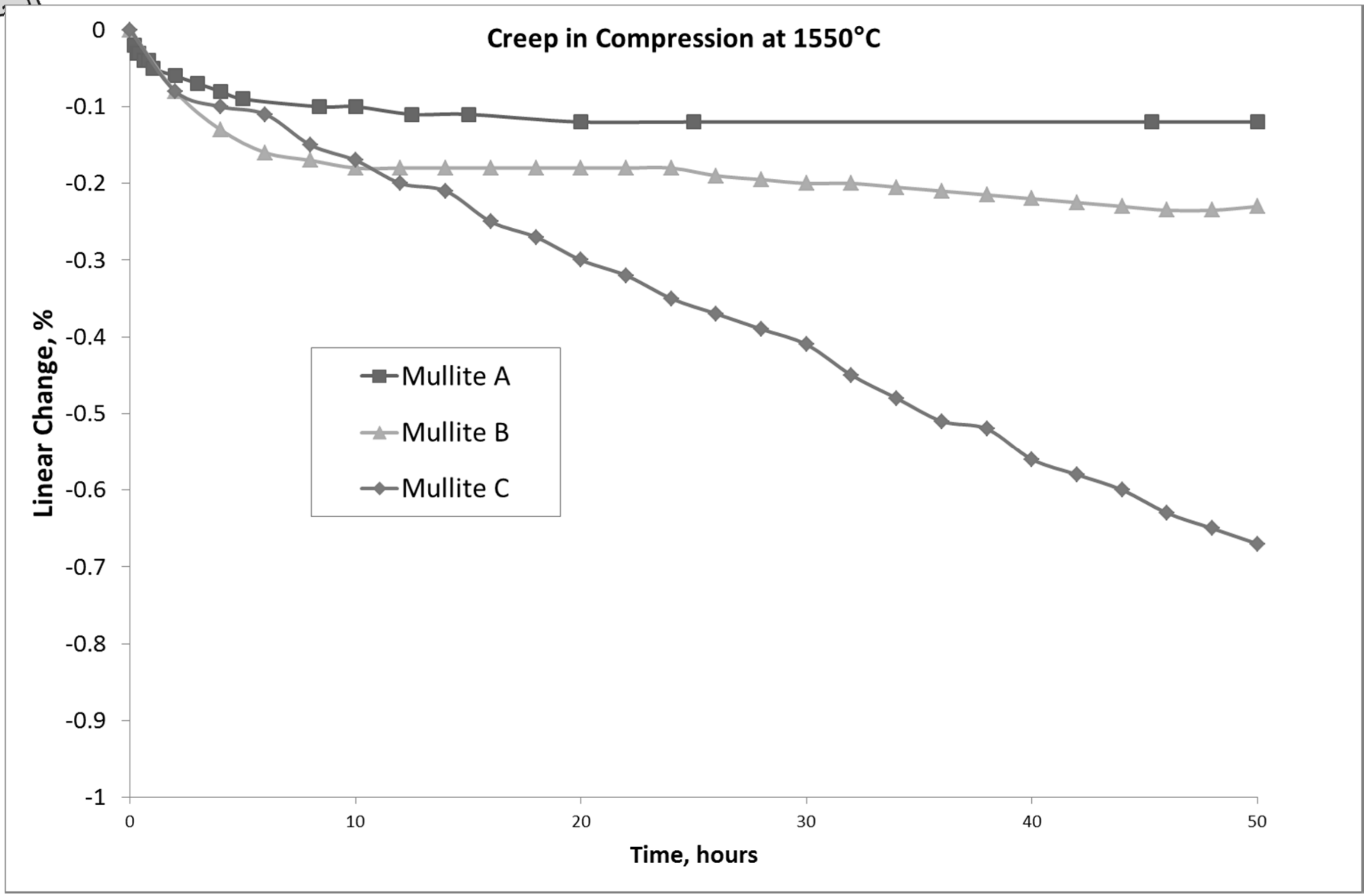
Restrained Expansion

- Excess stresses
- Bulk Spalling

- Can allow other problems to start

- Expansion movements becoming fouled

Creep


Creep in Compression at 1550°C
Linear Change, %
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1
0
10
20
30
40
50
Time, hours
Mullite A
Mullite B
Mullite C

Thank You For Your Attention