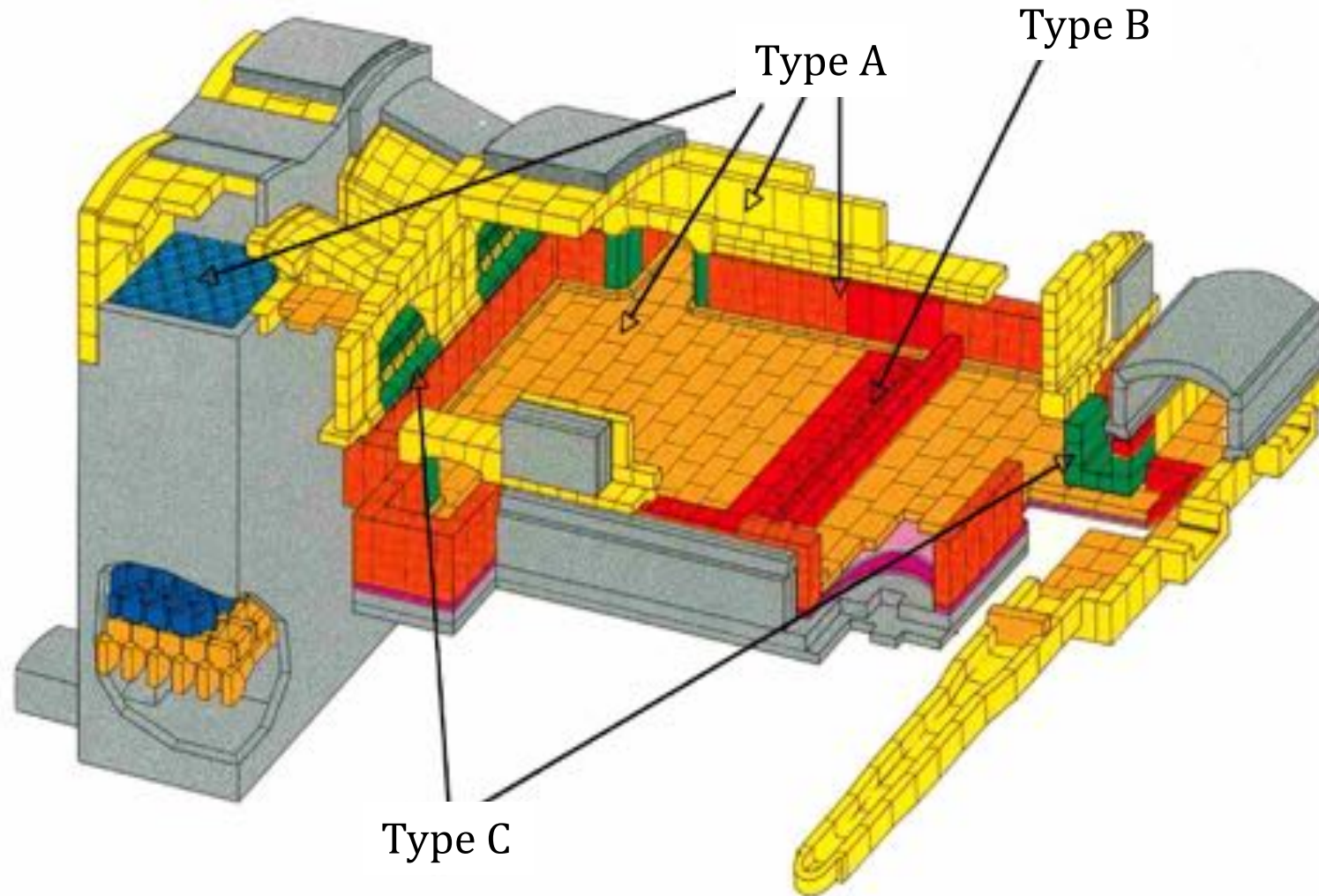
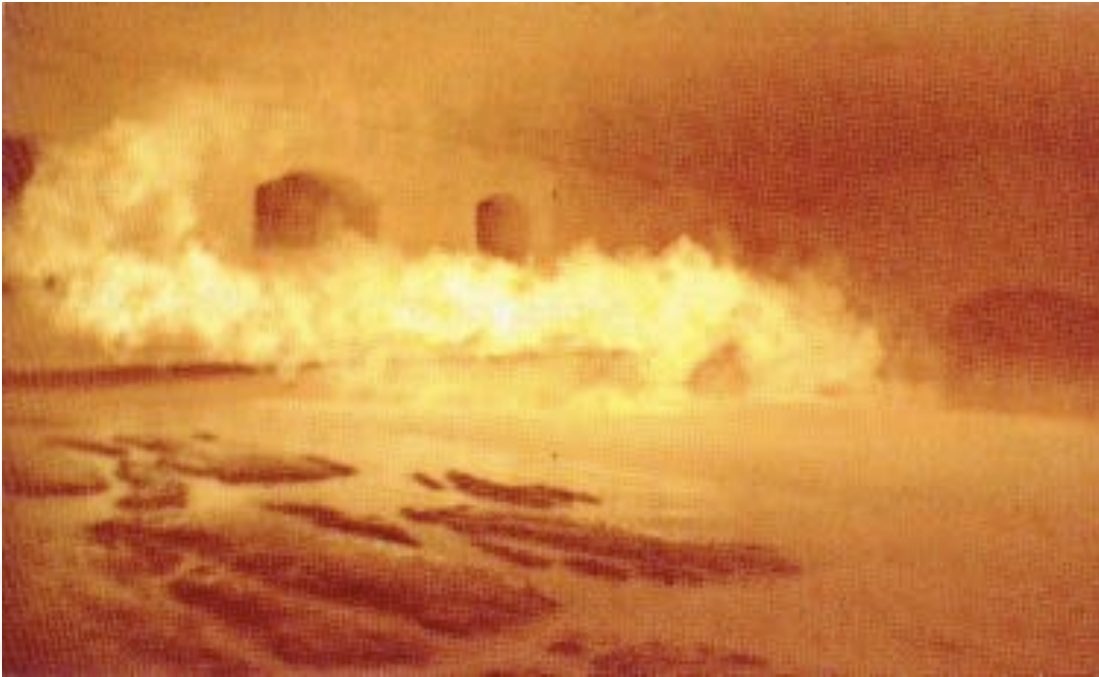


Refractories

Fundamentals of inorganic glasses, A.K. Varshneya, The society of glass technology, 2006 – Ch. 20



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Common refractories

Type	Composition	Maximum use temperature in oxygen		Thermal conductivity, kcal/min °C			Refractoriness under load of 197 kPa (28.5 psi)	
		°C	°F	At 300 °C (570 °F)	At 600 °C (1120 °F)	At 1200 °C (2190 °F)	°C	°F
Silica	93–96% SiO ₂	1700	3090	0.8–1.0	1.2–1.4	1.6–1.8	1650–1700	3000–3090
Fireclay	15–45% Al ₂ O ₃ 55–80% SiO ₂	1300–1450	2370–2640	0.8–0.9	1.0–1.2	2.5–2.8	1250–1450	2280–2640
Magnesite	80–95% MgO	1800	3270	3.8–9.7	2.8–4.7	2.5–2.8	1500–1700	2730–3090
Chromite	30–45% Cr ₂ O ₃ 14–19% MgO 10–17% Fe ₂ O ₃ 15–33% Al ₂ O ₃	1700	3090	1.3	1.6	1.8	1400–1450	2550–2640
Chrome magnesite	>60% MgO Fe ₂ O ₃ , Al ₂ O ₃	1800	3270	1.9–3.5	1.4–2.5	1.8	1500–1600	2730–2910

Produced by melting/casting or sintering (liquid phase)

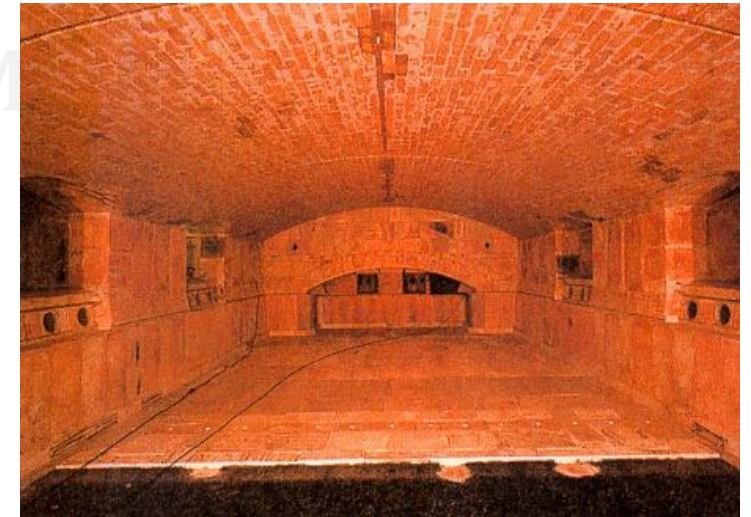
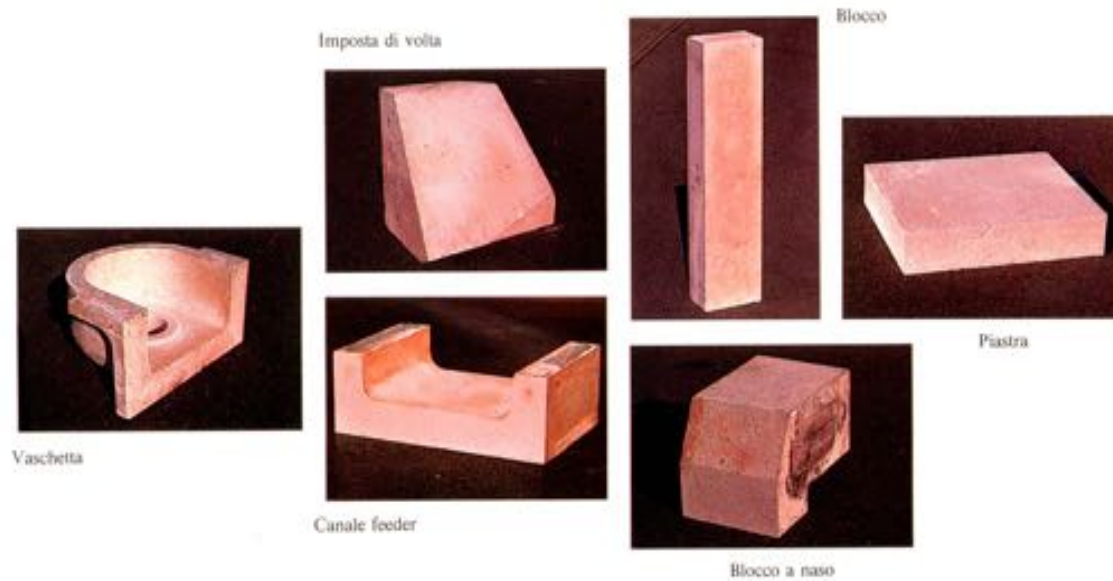
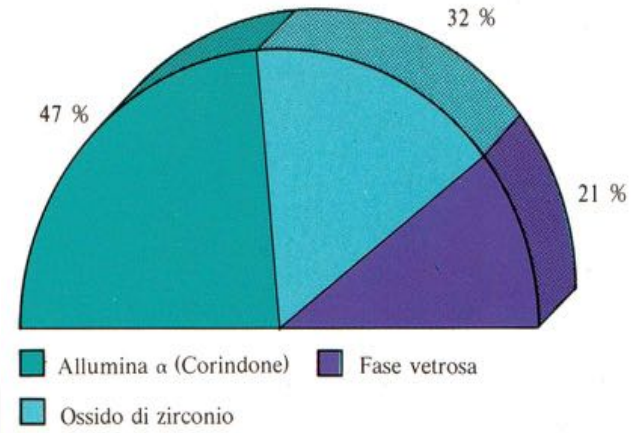
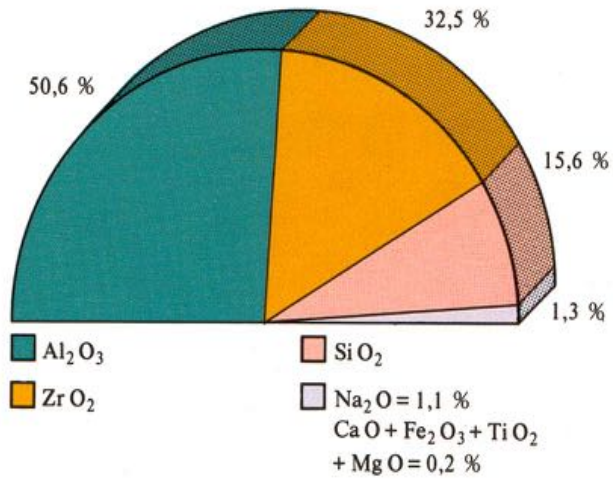
Refractory oxides

Type	Composition	Melting point		Maximum use temperature in oxygen		Thermal conductivity, kcal/min °C				Refractoriness under load of 196 kPa (28.4 psi)	
		°C	°F	°C	°F	At 100 °C (212 °F)	At 500 °C (930 °F)	At 1000 °C (1830 °F)	At 1500 °C (2730 °F)	°C	°F
Aluminum oxide	100% Al ₂ O ₃	2015	3660	1950	3540	26.0	9.4	5.3	5.0	2000	3630
Barium oxide	100% BaO	2550	4620	2400	4350	189.0	56.3	17.5	13.5	2000	3630
Magnesium oxide	100% MgO	2800	5070	2400	4350	31.0	12.0	6.0	5.4	2000	3630
Silicon dioxide	100% SiO ₂	...	...	1200	2190	0.8	1.4	1.8	...	...	...
Mullite	72% Al ₂ O ₃ 28% SiO ₂	1830(a)	3325(a)	1850	3362	5.3	3.8	3.4	...	...	...

(a) Incongruent

Produced by sintering (solid state)

type A: AZS refractory material



Fused-cast refractories

raw materials (oxides)



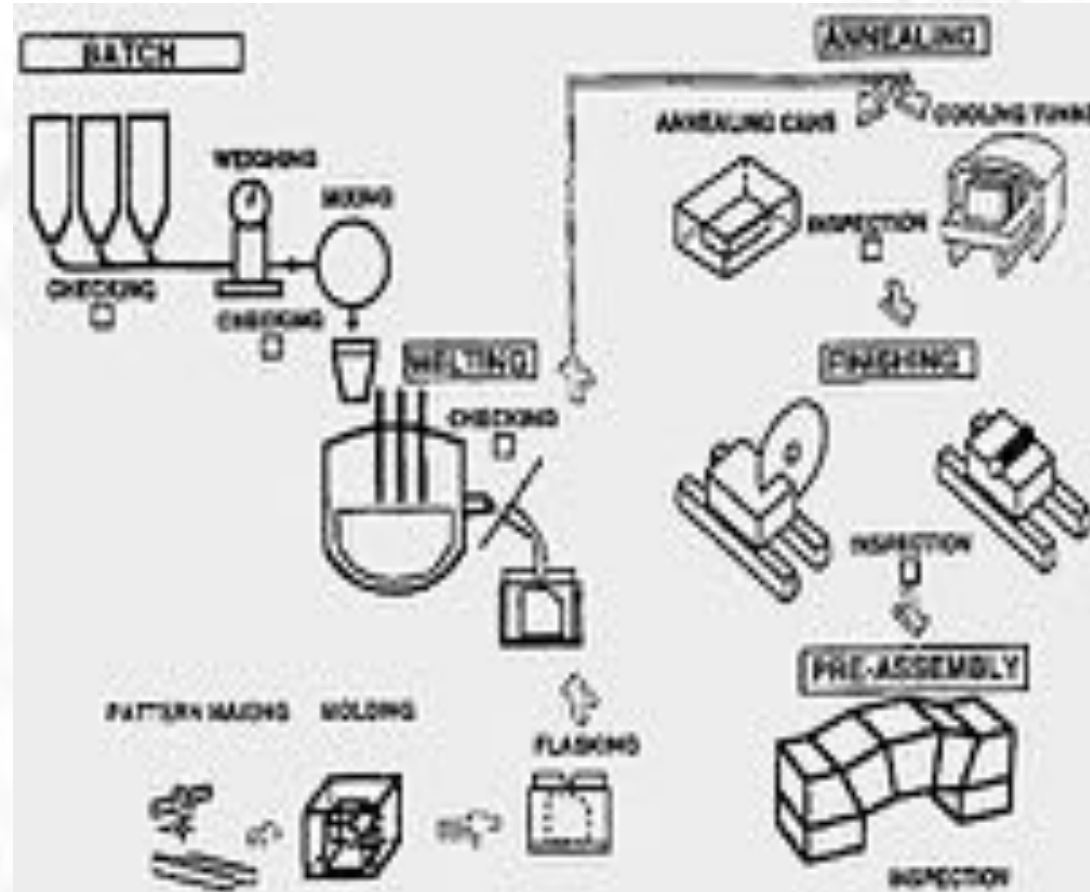
arc electric furnace melt



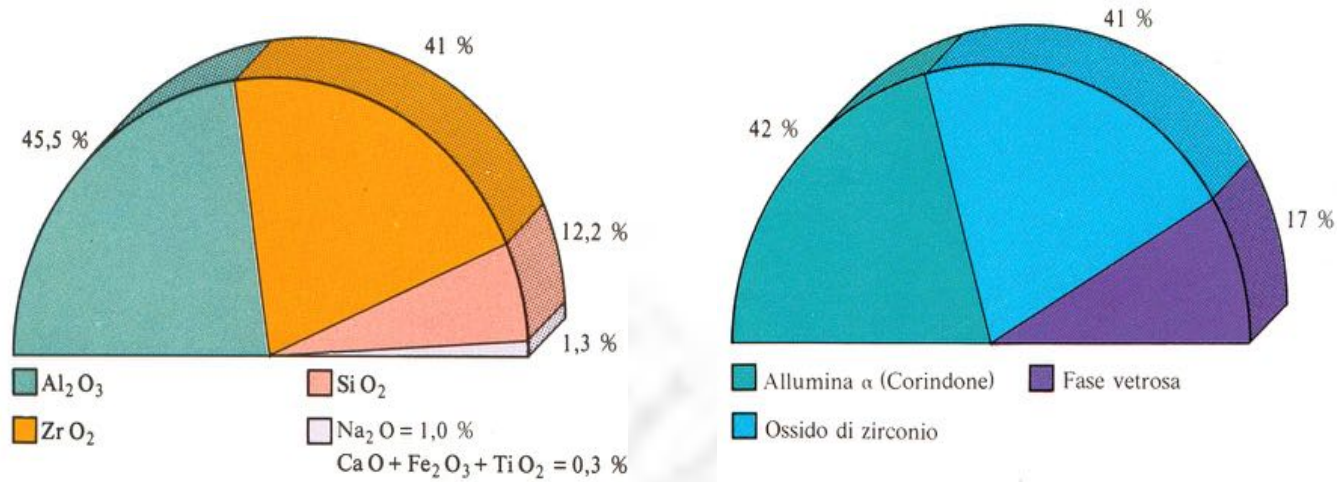
fuse-cast (sand mould)



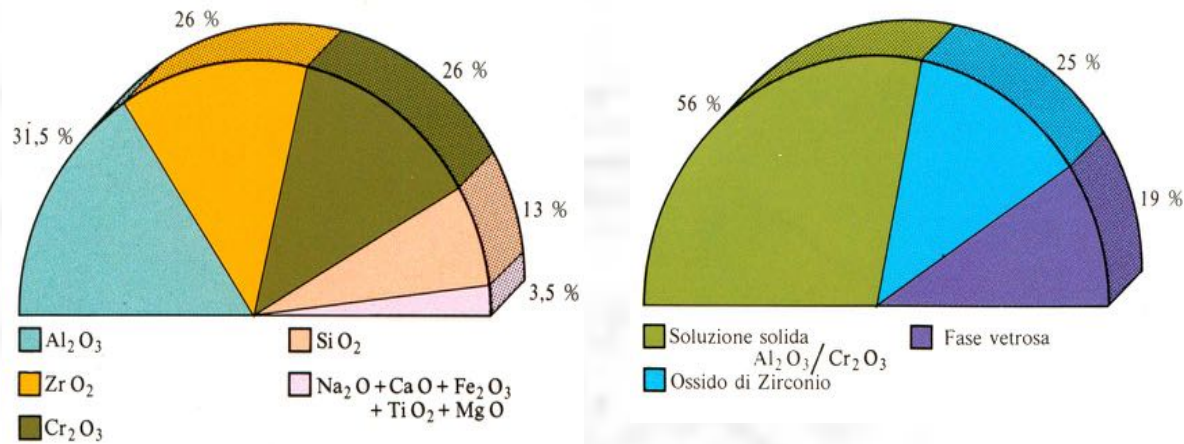
cut - machining



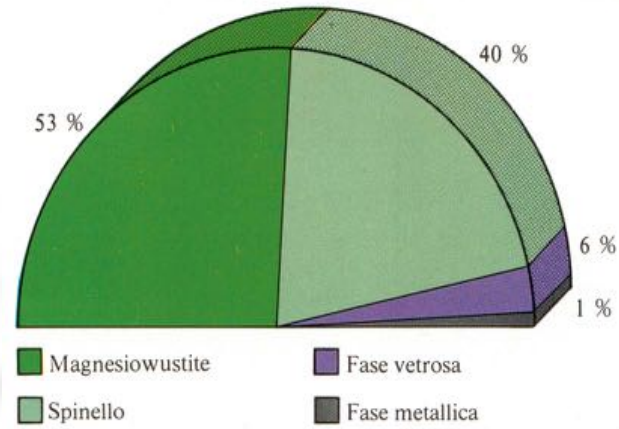
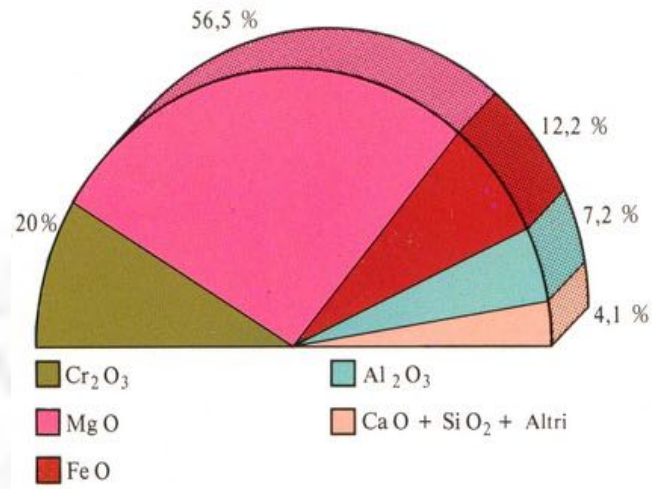
type B: AZS



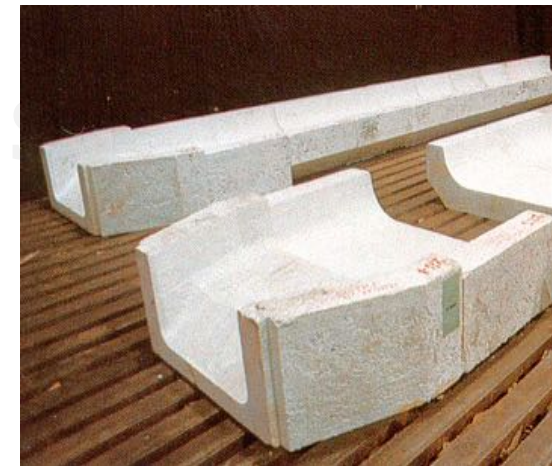
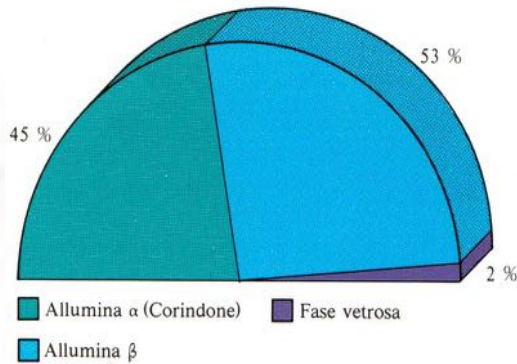
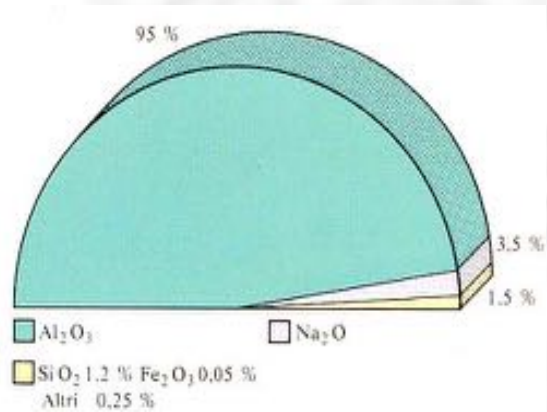
type C: AZS with Cr_2O_3 (higher mechanical and chemical resistance)



type D: chromia-magnesia refractory (for alkaline glass)

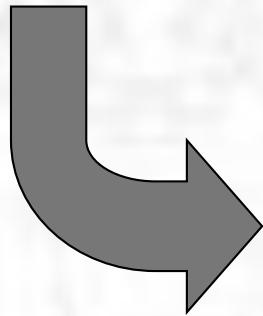
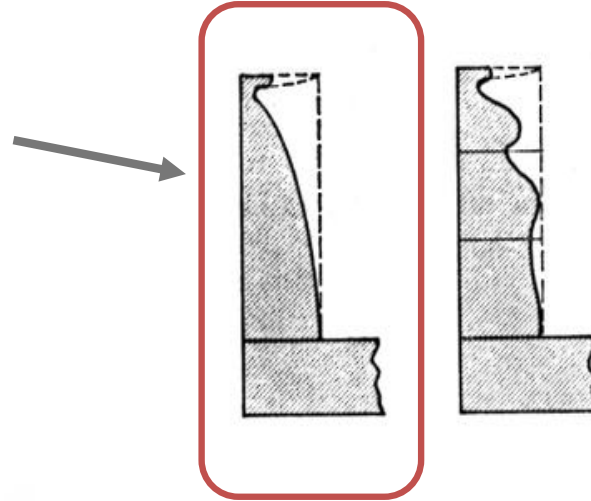


type E: alumina refractory (higher mechanical resistance)



Problems associated to melting

- *refractories corrosion (solubilization, melting)*
- *electrodes corrosion (oxidation)*
- *volatilization of raw materials*
- *redox reactions*
- *devitrification*



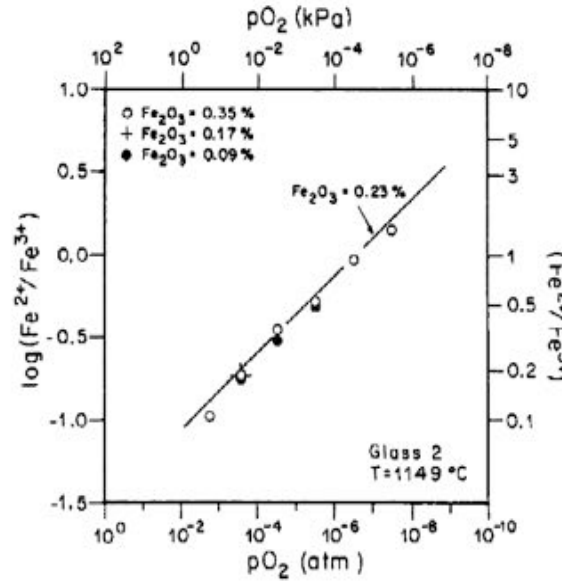
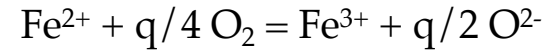
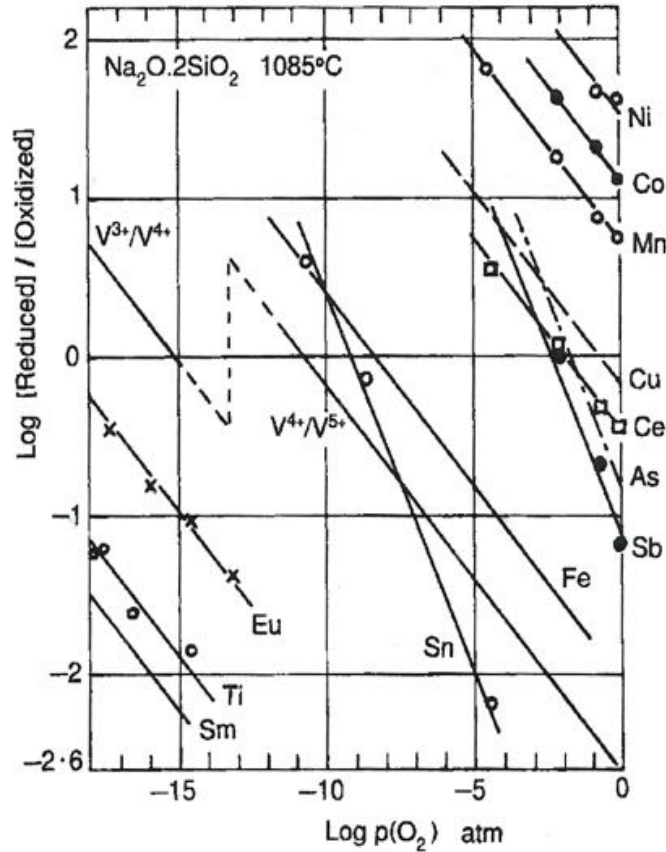
defects in the melt

- inclusions (refractory stones)
- bubbles
- chemical inhomogeneities
- colour

V.M. Sglavo – 2020

Redox reactions

→ oxygen partial pressure



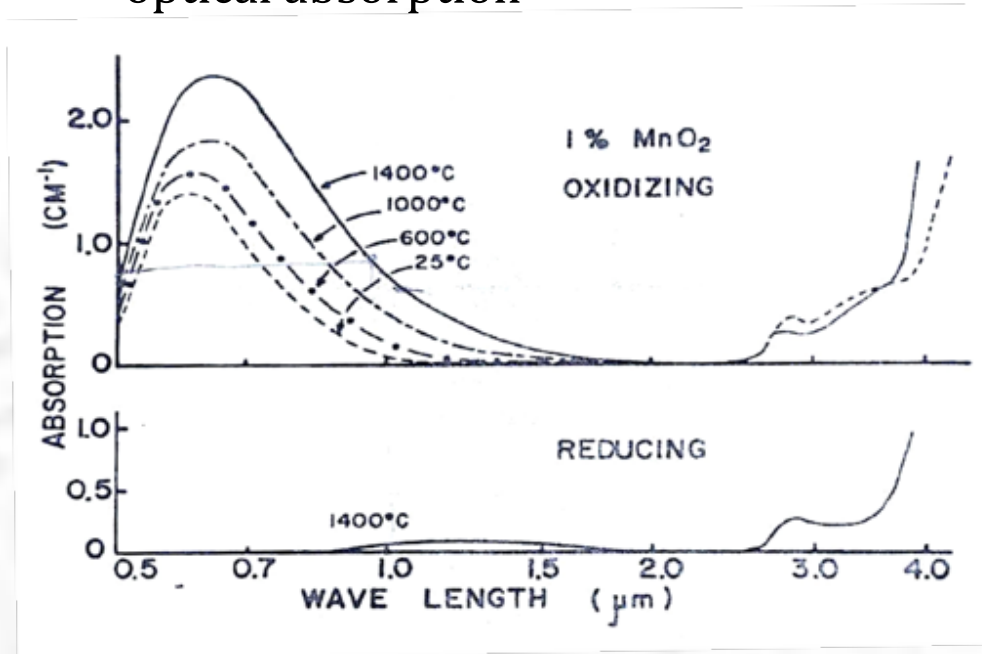
interaction between ionic species

Metal	Multivalent Ion couples	
Chromium	Cr ³⁺	Cr ⁶⁺
Manganese	Mn ²⁺	Mn ³⁺
Cerium	Ce ³⁺	Ce ⁴⁺
Vanadium	V ³⁺	V ⁵⁺
Copper	Cu ⁺	Cu ²⁺
Arsenic	As ³⁺	As ⁵⁺
Antimony	Sb ³⁺	Sb ⁵⁺
Iron	Fe ²⁺	Fe ³⁺
Tin	Sn ²⁺	Sn ⁴⁺

increasing
tendency to
oxidation

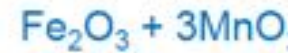
MnO₂ – containing glass

optical absorption



typical ions in glass: Mn³⁺, Mn²⁺

Colored glass:



faint blue/faint green



violet

Flint glass, Fe₂O₃ < 0.1 wt%

As decolorizer:

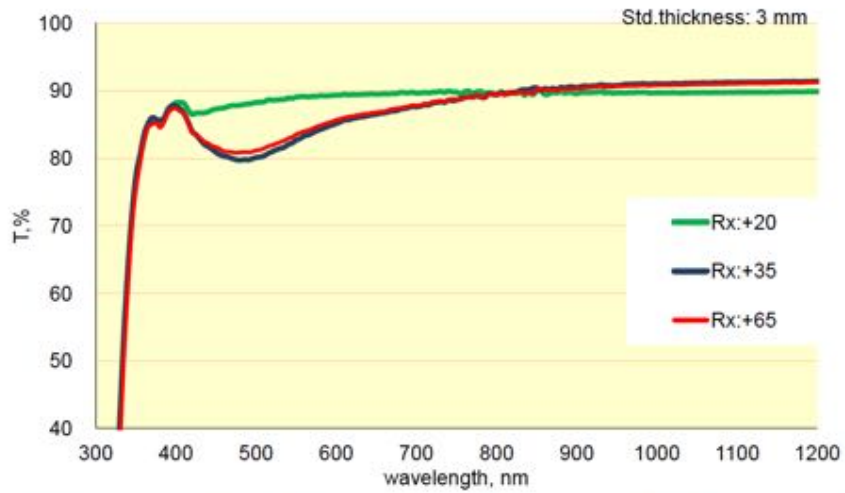


In UV radiation :



solarization effect

$Fe_2O_3:0.050\%$, $MnO_2:0.4\%$

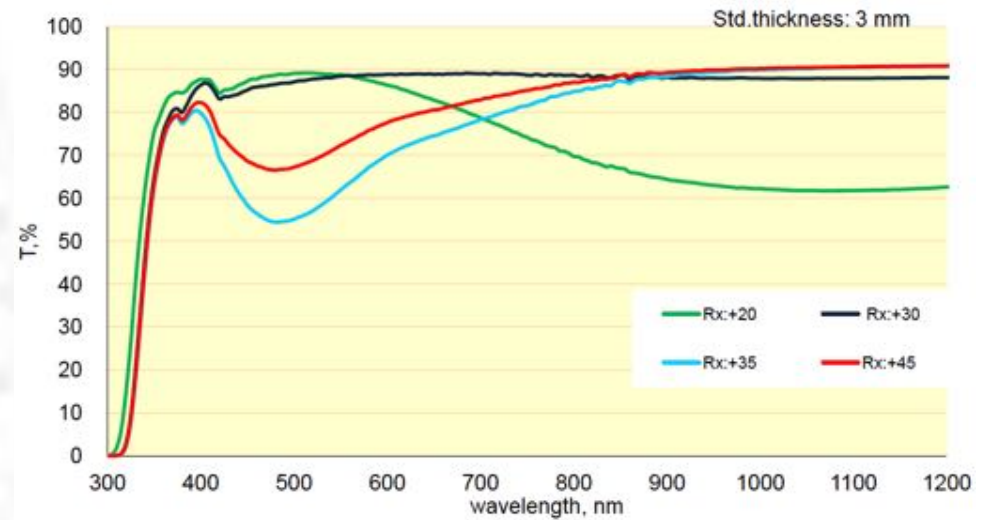


+20 +25 **+35** +45 +65

$Rx \approx Oxidized / Reduced (MnO_2)$



$Fe_2O_3:0.100\%$, $MnO_2:0.8\%$



+20 +30 **+35** +45