New ceramic bricks based on pretreated MSW bottom ash

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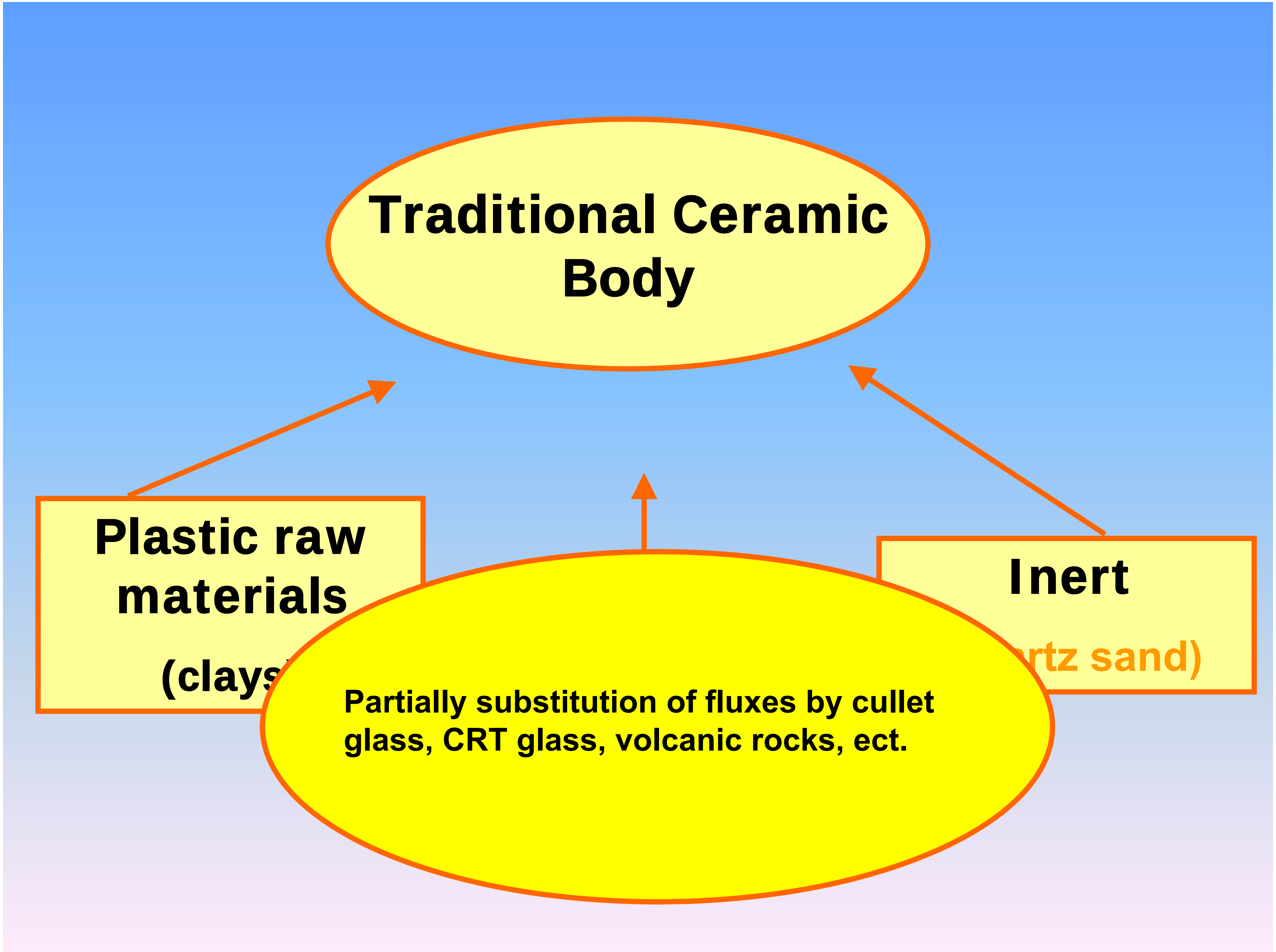
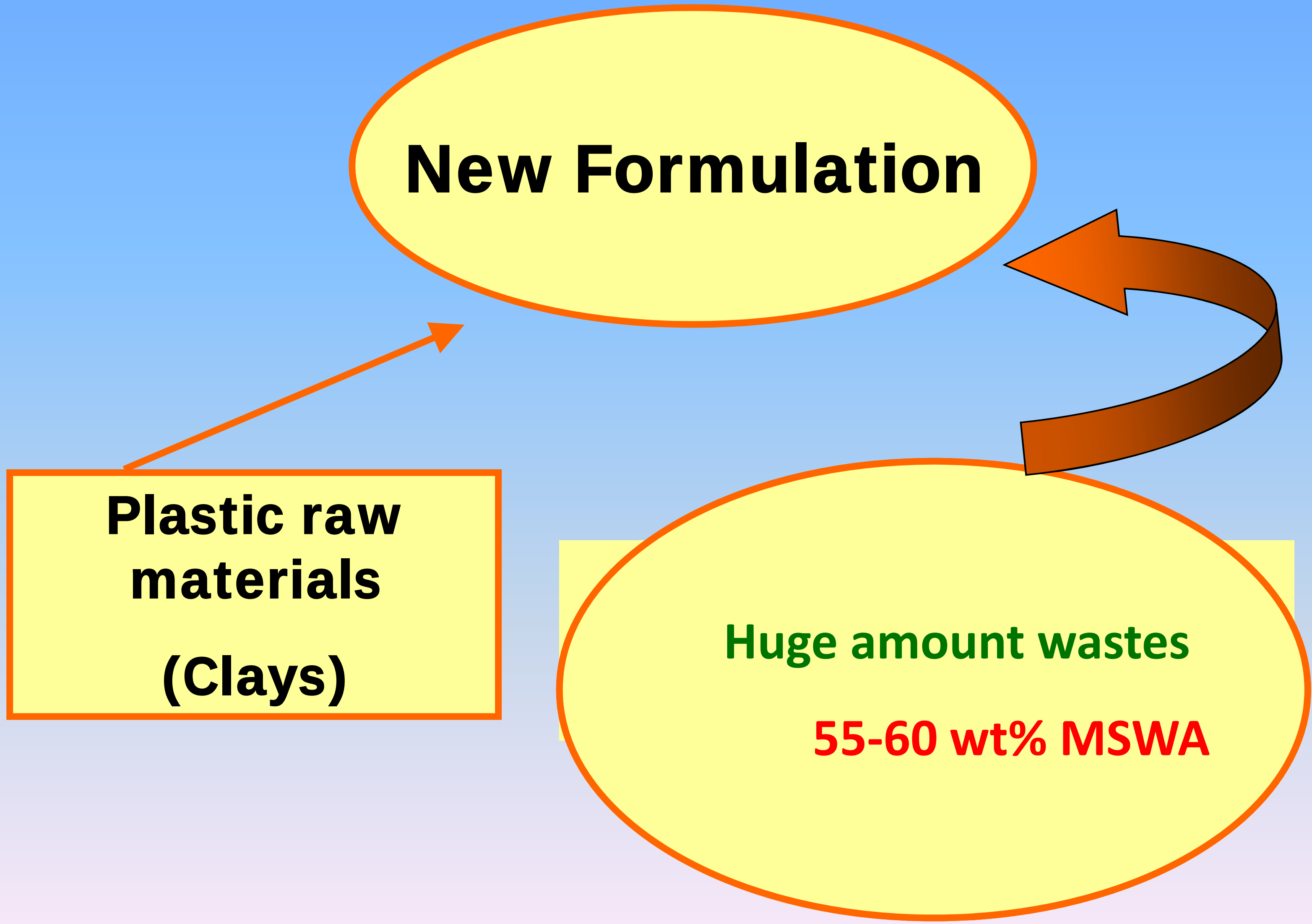

Traditional Ceramic Body
Plastic raw materials
(clays
Inert
rtz sand)
Partially substitution of fluxes by cullet glass, CRT glass, volcanic rocks, ect.

AIM OF THE WORK



Secondary Raw Material

Pre-treated bottom MSW ash

Technological Recovery Process

Sorting → ***Physic-Mechanical treatments*** *aging, Fe and non Fe metals separation, crushing, sieving, washing,…* →

Non hazardous silica rich material

Experimental procedure

55-60 wt% SRM
F (<2 mm)
L (>2 mm)

40-45 wt% CLAY

Additional burning at 600 °C

DRY GRINDING AND SIEVING < 75 μm

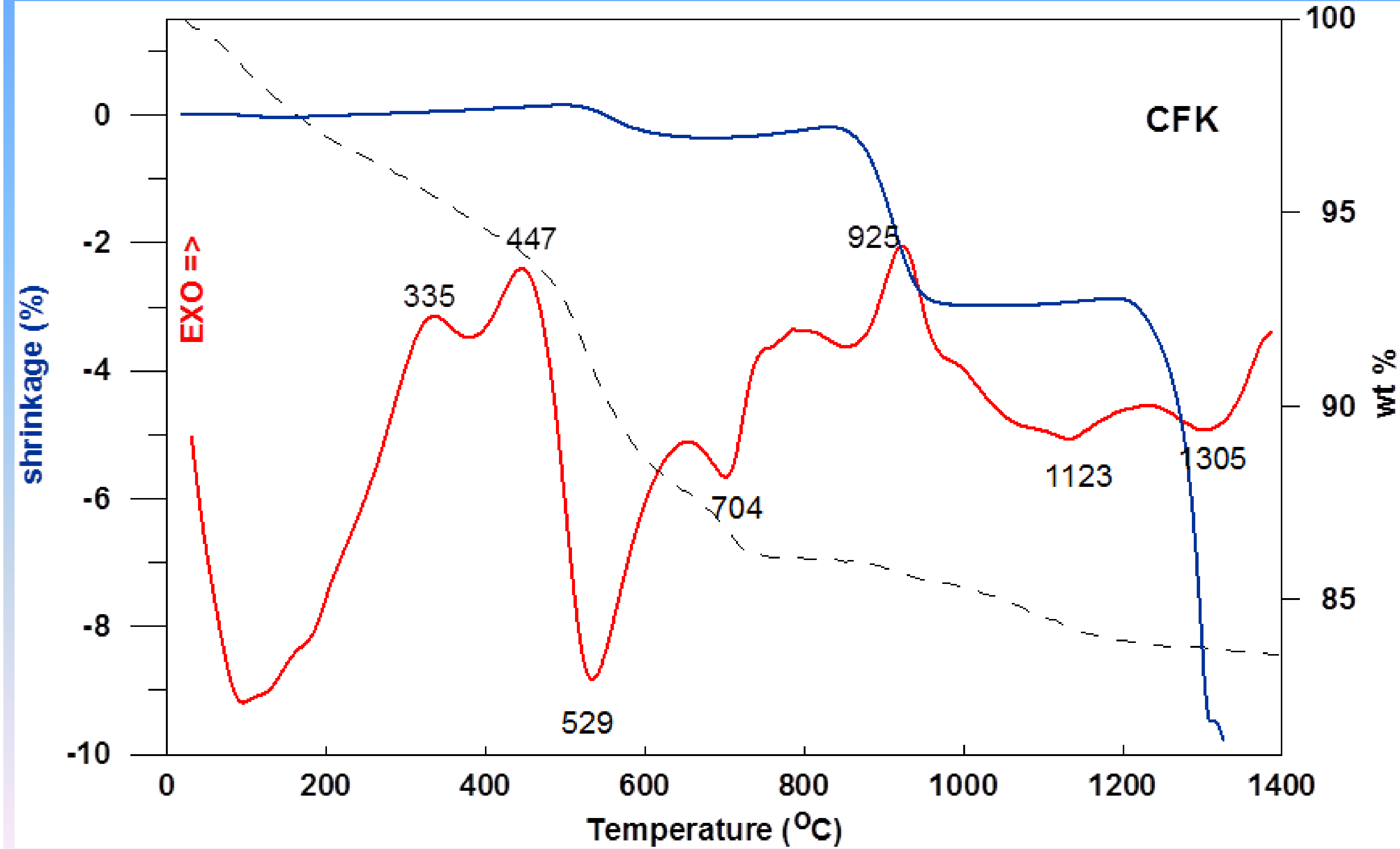
Umidification (6%wt)
Pressing (40 MPa) in 50x5x4 mm 100x50x6 mm forms

Sintering in optical dilatometer and in electrical laboratory furnace

Chemical compositions of the raw materials (wt%)			
OXIDE	K	F (<2 mm)	L (>2 mm)
SiO_2	47,1	30,3	47,4
TiO_2	0,2	1,1	0,8
Al_2O_3	36,1	13,3	10,0
Fe_2O_3	1,0	10,8	4,4
CaO	0,4	20,8	18,8
MgO	0,3	2,8	2,9
K_2O	1,1	0,9	1,0
Na_2O	0,6	1,9	4,5
B_2O_3	0,0	0,3	0,6
MnO	0,0	0,8	0,3
ZnO	0,0	0,8	0,3
PbO	0,0	0,4	0,3
SO_3	0,0	1,7	1,0
P_2O_3	0,0	2,0	1,3
CuO	0,0	0,7	0,5
Cloride	0,0	0,5	0,0
Oders	0,0	0,1	0,2
L.O.I	12,5	<u>11,7</u>	<u>5,6</u>
Total	99,3	101,0	99,8

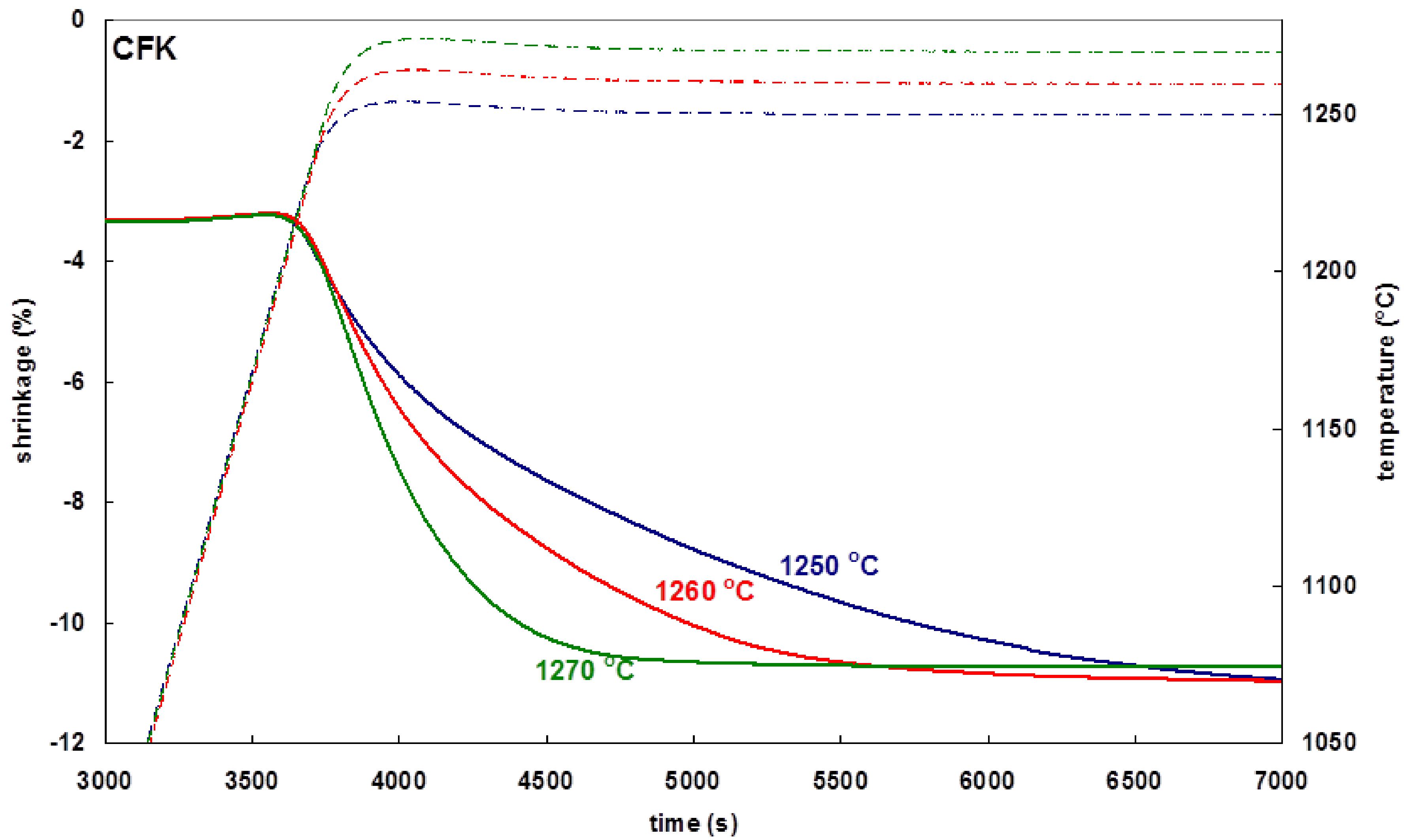
THERMAL CHARACTERIZATION

Non-isothermal DTA-TG and DIL curves

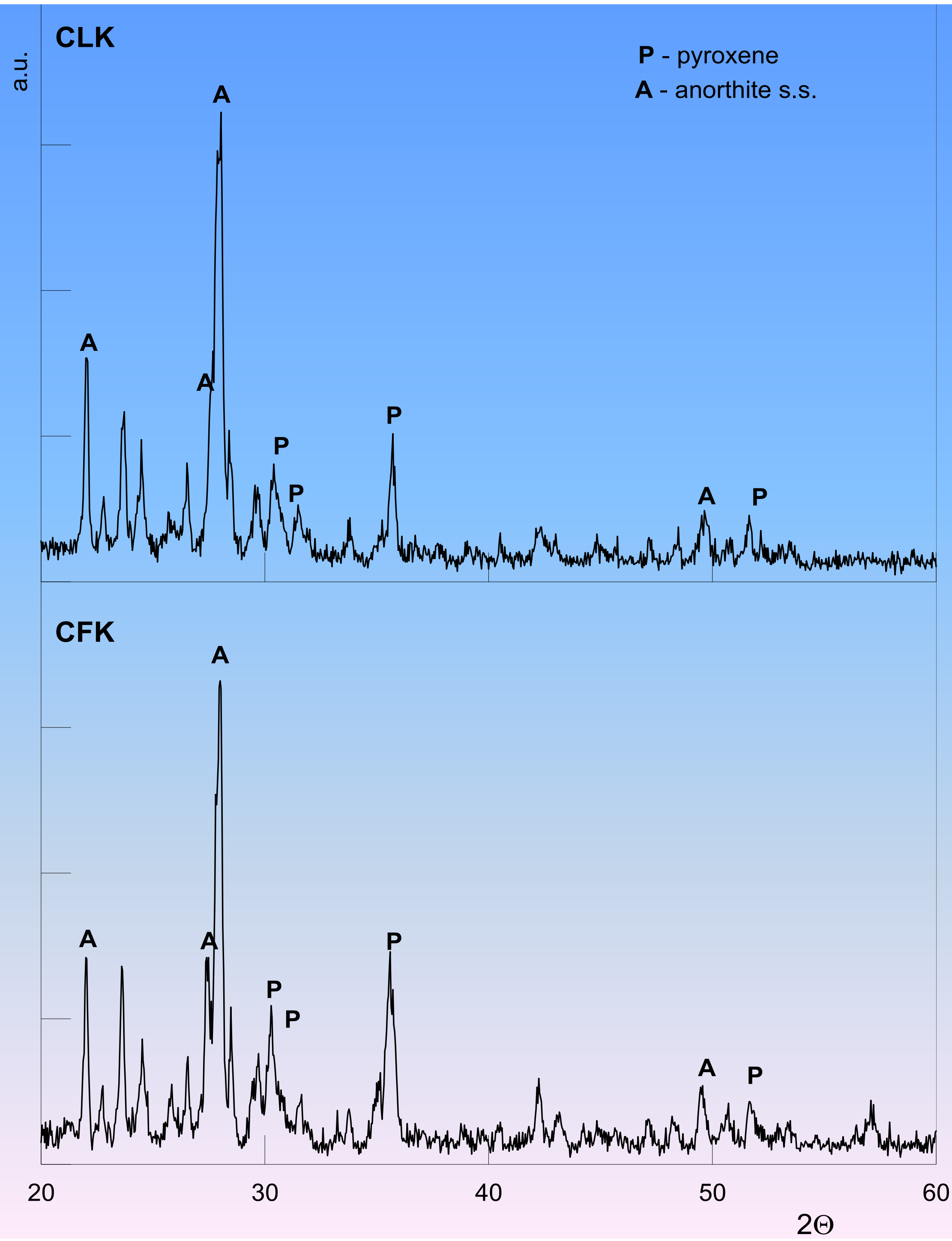


THERMAL CHARACTERIZATION

isothermal DTA-TG and DIL curves

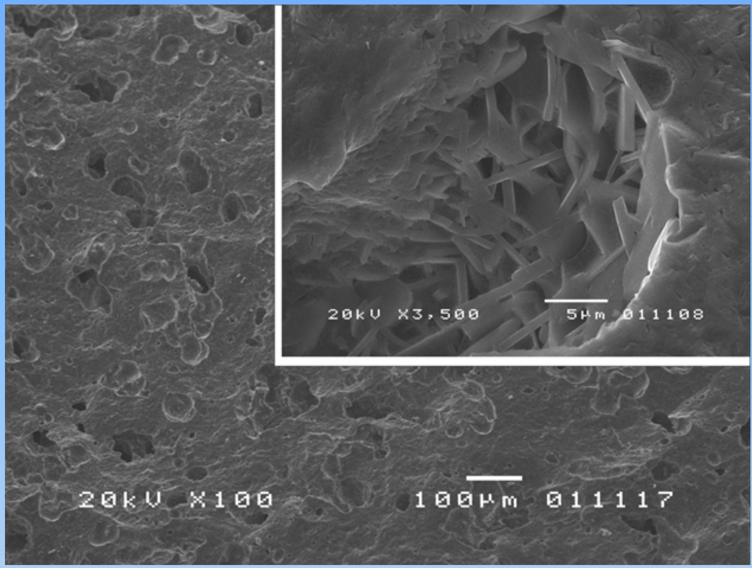


XRD of final ceramics

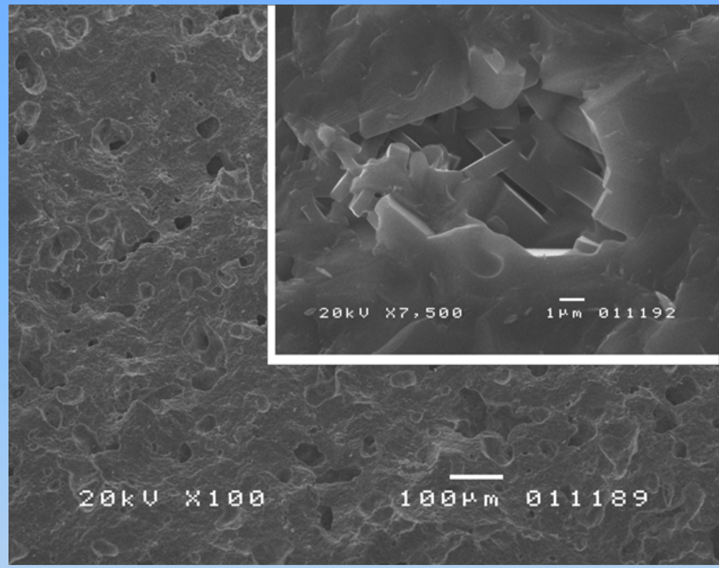


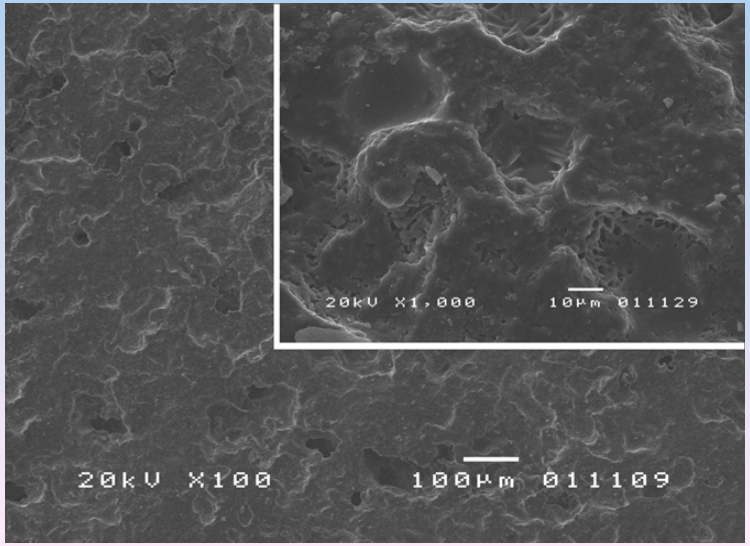
STRUCTURE OF THE FINAL CERAMICS

CLK **CFK**

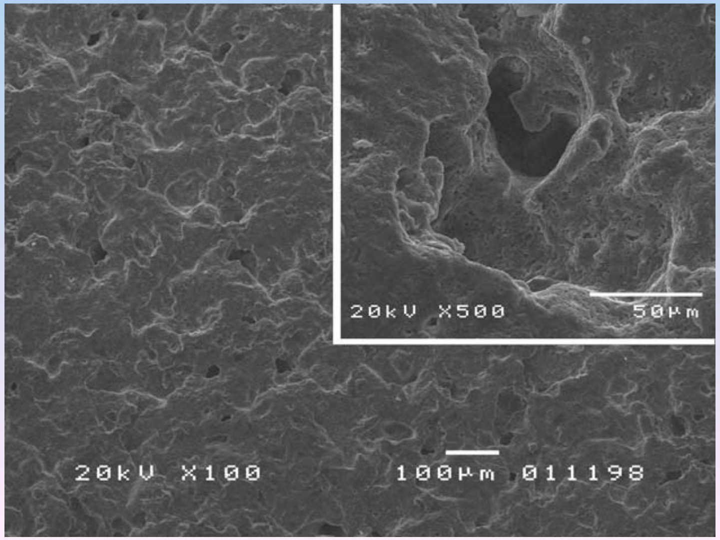


fracture





surface



PROPERTIES

Linear shrinkage (LS%), water absorption (WA%), densities, porosities, bending strength (BS) and Young's modulus (E)

Properties	CFK	CLK
LS (%)	7.5	4.5
WA (%)	2.1	1.6
ρ_a (g/cm^3)	2.3	2.1
P_T (%)	23	20
BS(MPa)	53	42
E (GPa)	49	44

Additional burning at 600 °C

(work in progress)

Chemical composition (wt %) of raw materials

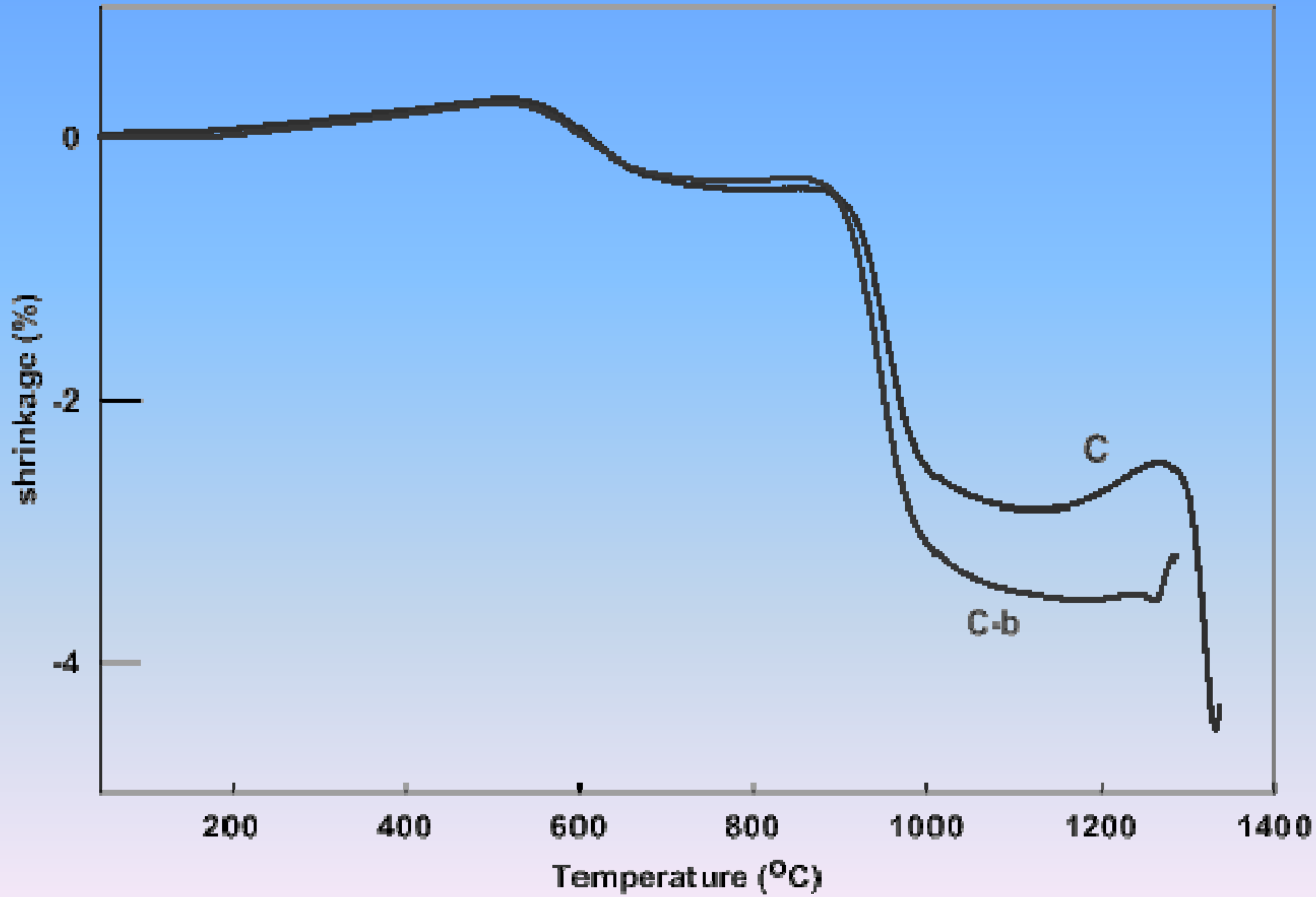
OXIDE	K	SRM	SRM-b
SiO_2	52,5	46,8	48,7
TiO_2	0,5	0,7	0,8
Al_2O_3	33,3	9,8	10,2
Fe_2O_3	0,6	4,3	4,5
CaO	0,2	18,6	19,3
MgO	0,4	2,9	3,0
K_2O	0,9	1,0	1,0
Na_2O	0,1	4,5	4,7
B_2O_3	0,0	0,6	0,6
MnO	0,0	0,3	0,3
ZnO	0,0	0,3	0,3
PbO	0,0	0,3	0,3
SO_3	0,0	1,0	1,0
P_2O_3	0,0	1,2	1,3
CuO	0,0	0,5	0,5
Others	0,0	0,2	0,2
L.O.I	11,7	**7,3**	**3,1**

Chemical composition (wt %) of the studied ceramics

OXIDE	C	C-b	C-b-Al	C-b-Na
SiO_2	54,4	54,2	51,5	52,7
TiO_2	0,7	0,7	0,7	0,7
Al_2O_3	22,5	22,2	**26,9**	22,1
Fe_2O_3	2,9	3,1	2,7	2,8
CaO	11,4	11,6	10,5	10,7
MgO	2,0	2,0	1,8	1,8
K_2O	1,1	1,0	1,0	1,0
Na_2O	2,8	2,8	2,6	**5,9**
B_2O_3	0,4	0,4	0,3	0,3
MnO	0,2	0,2	0,2	0,2
ZnO	0,2	0,2	0,2	0,2
PbO	0,2	0,2	0,2	0,2
SO_3	0,6	0,6	0,5	0,5
P_2O_3	0,7	0,8	0,7	0,7
CuO	0,3	0,3	0,3	0,3

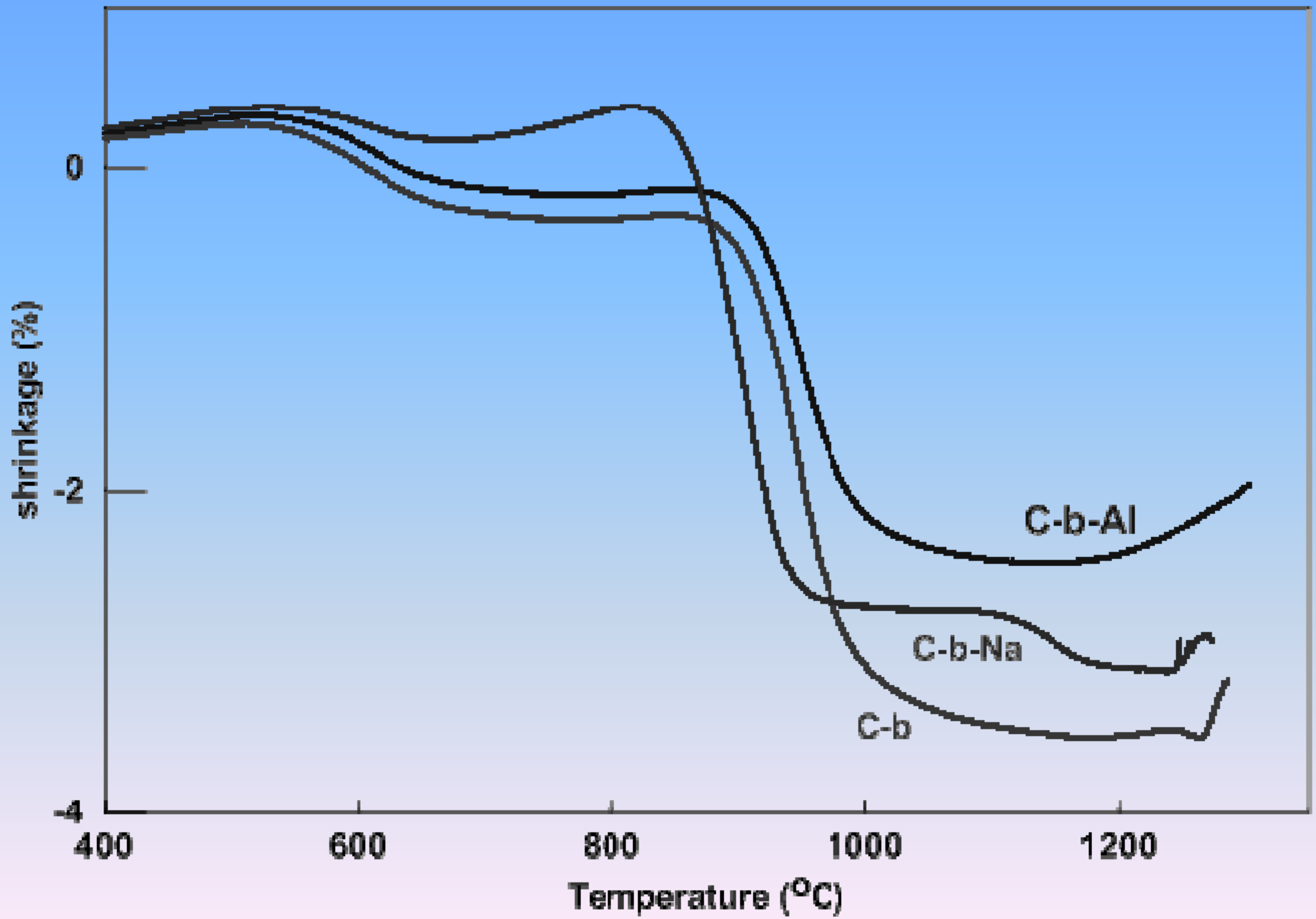
THERMAL CHARACTERIZATION

Non-isothermal dilatometric results of compositions C and C-b



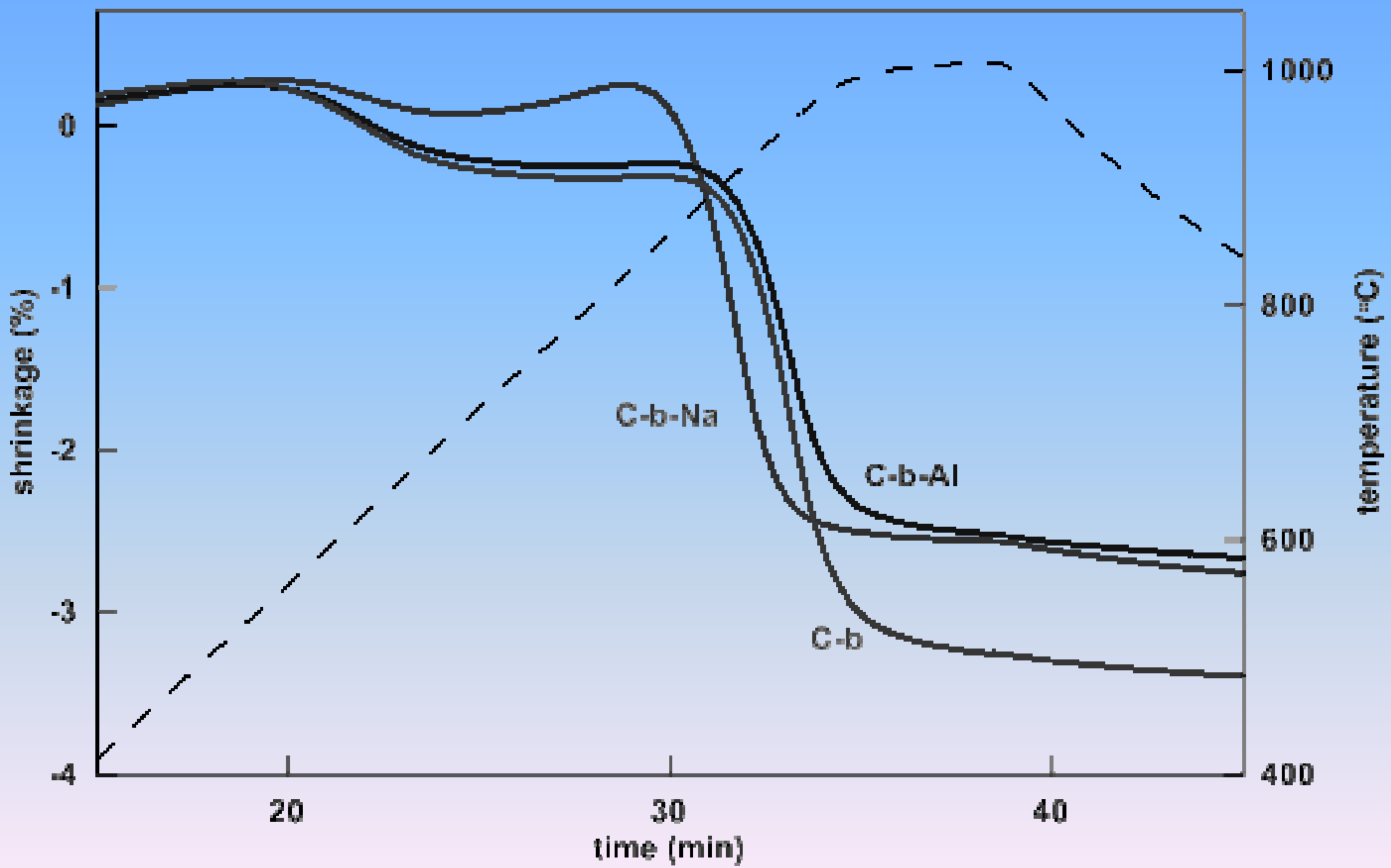
THERMAL CHARACTERIZATION

Non-isothermal dilatometric results of compositions C-b, C-b-Al and C-b-Na



THERMAL CHARACTERIZATION

Isothermal dilatometric results of compositions C-b, C-b-Al and C-b-Na

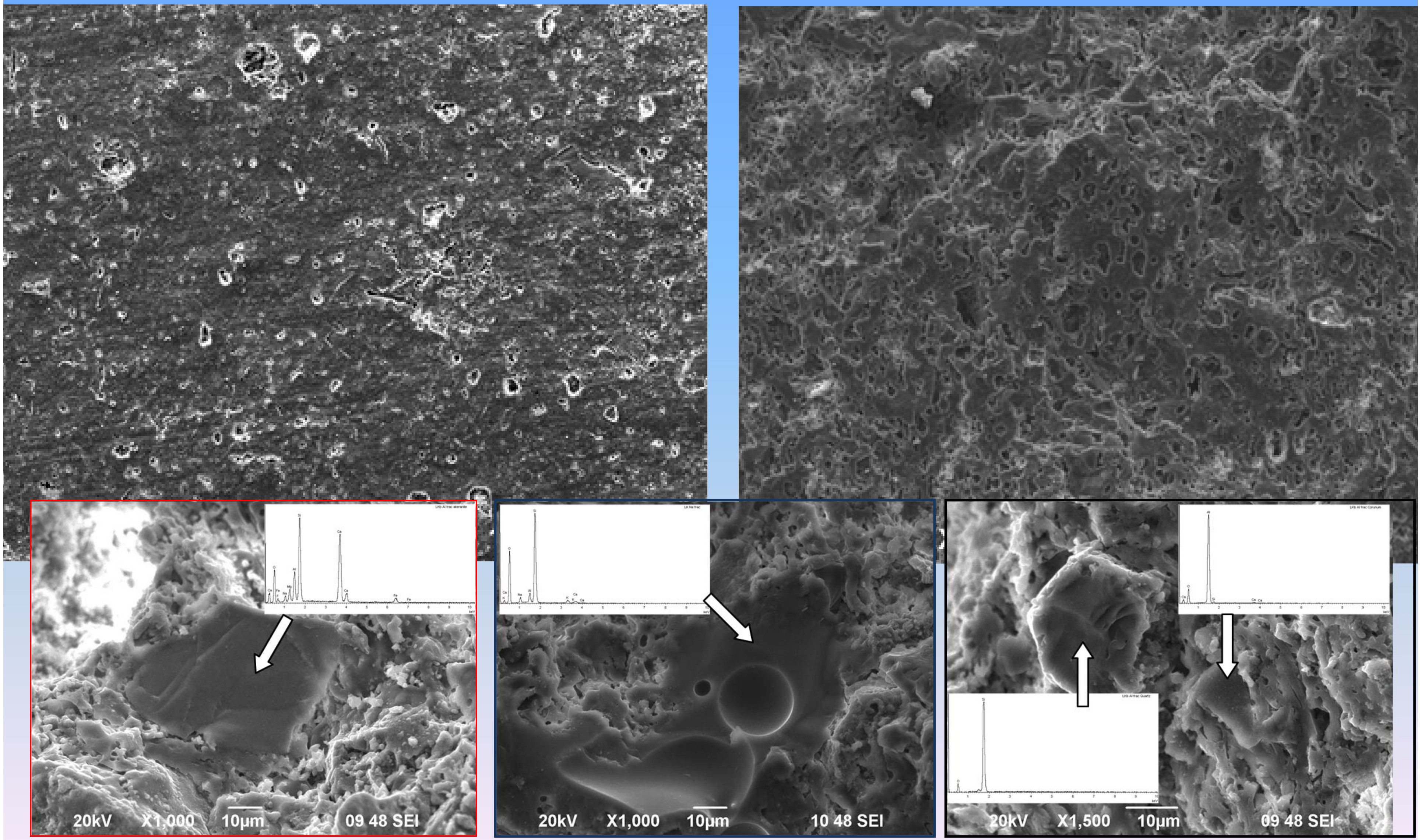


Density (g/cm^3), porosity (vol %) and water absorption of the final samples obtained for 5 min at 1000^{o}C

	C-b	C-b-Al	C-b-Na
apparent density (g/cm^3)	**1.86** ± 0.02	**1.95** ± 0.03	**1.92** ± 0.02
water absorption (%)	**14.5** ±0.5	**13.0** ± 0.5	**11.5** ± 0.5
total porosity (%)	**31**±1	**29**±1	**27**±1

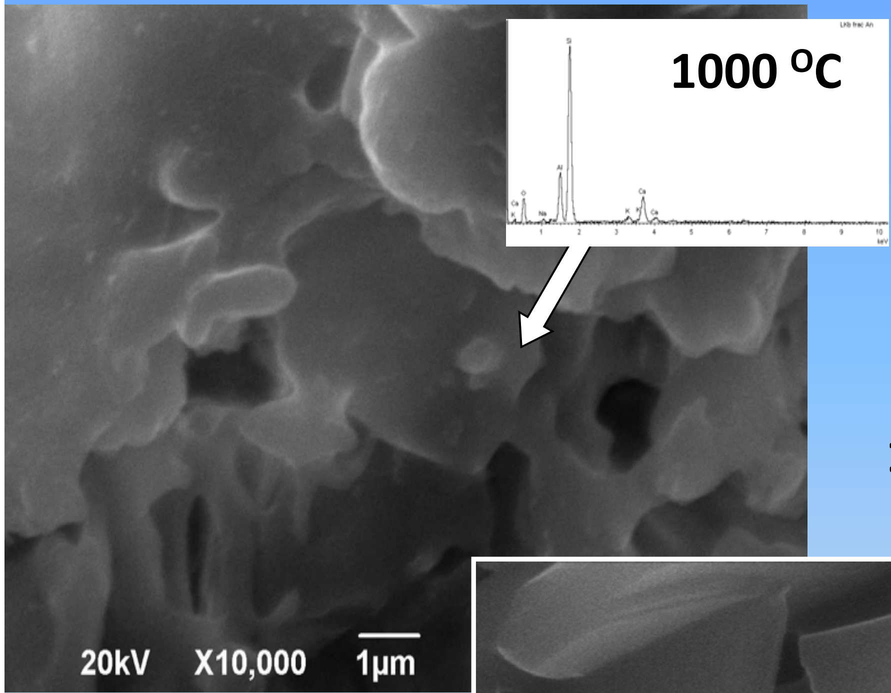
STRUCTURE OF THE FINAL CERAMICS

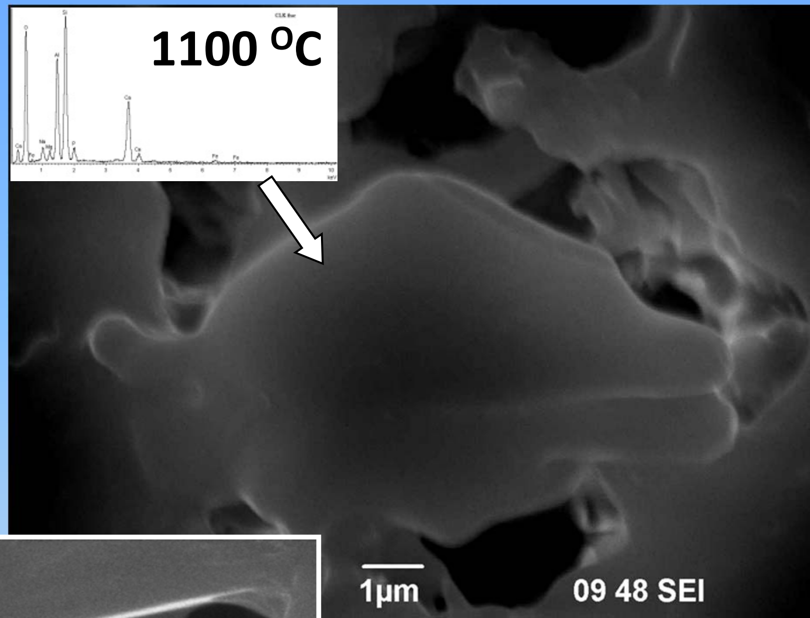
surface | 1000 ^{O}C | fracture



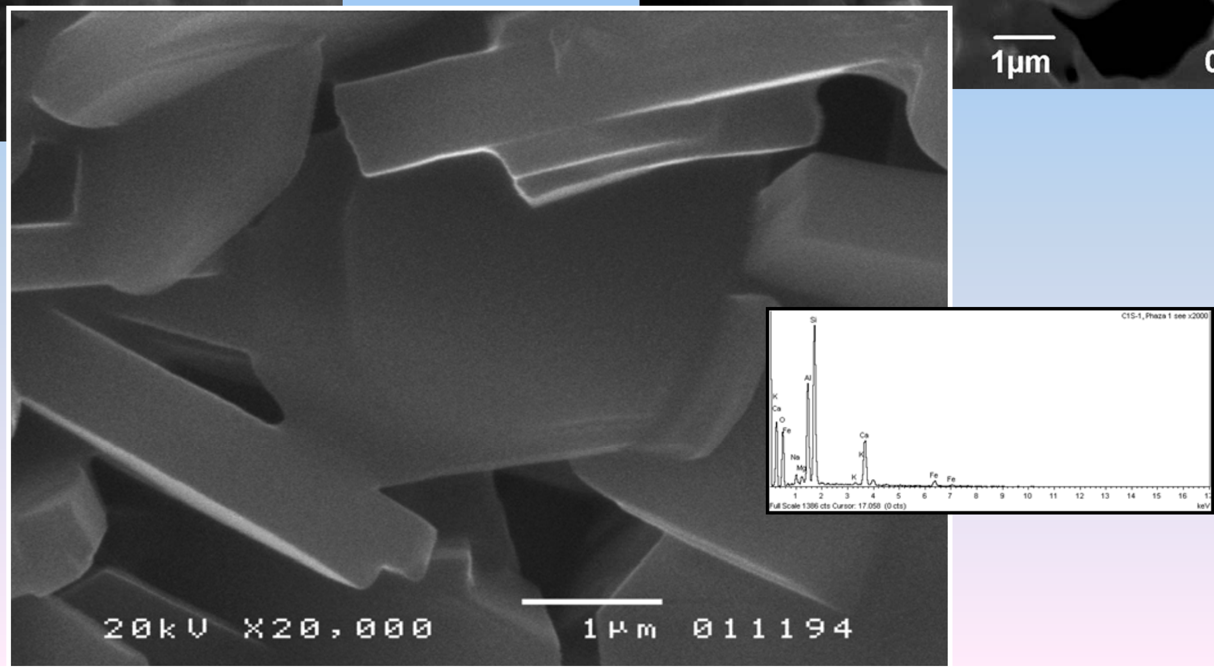
MICROSTRUCTURAL ANALYSIS

Development of main anorthite phase





1260°C



CONCLUSIONS

•New cheap ceramics, based on huge amount of industrial wastes, were synthesized at sintering temperatures of 1200-1250 °C and holding times of 10-30 min.

•The new compositions are characterized by an elevate crystallinity, resulting in improved mechanical properties.
•`
•The possibility to obtain samples with bricks structure after very short thermal treatment at low temperature is also demonstrated.

Thank You for the attention

Sintered glass-ceramic from iron-rich MSWA

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- *The vitrification is considered as an ultimate method for immobilization of hazardous and non-inert industrial wastes because during glass melting the harmful elements are chemically bonded in the durable amorphous network.*

- *However this procedure is economically favoured only if materials with commercial value are obtained.*

- *From this point of view, the synthesis of quality glass-ceramics seems to be one of the most promising solutions.*

- *A significant part of the hazardous and non-inert industrial wastes industrial residues are iron-rich.*

Slagsitall Production

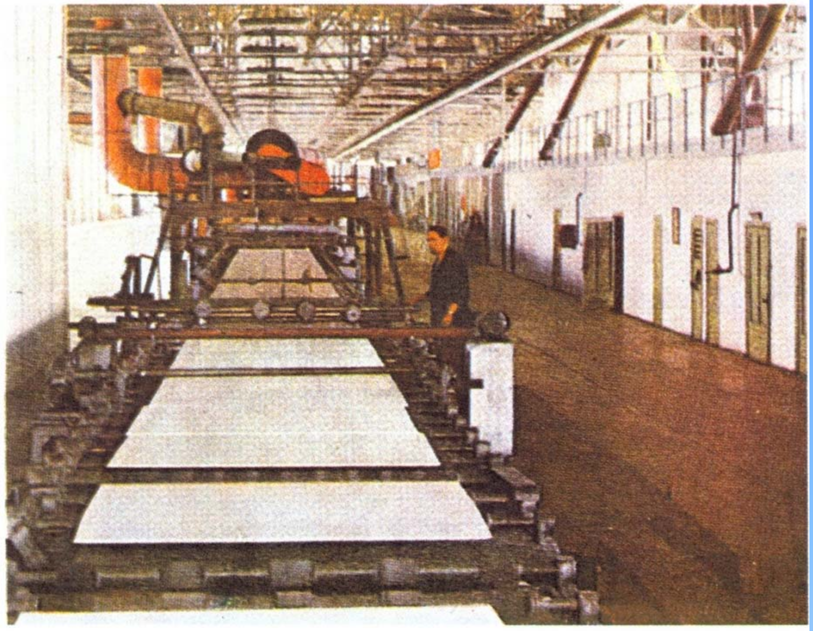
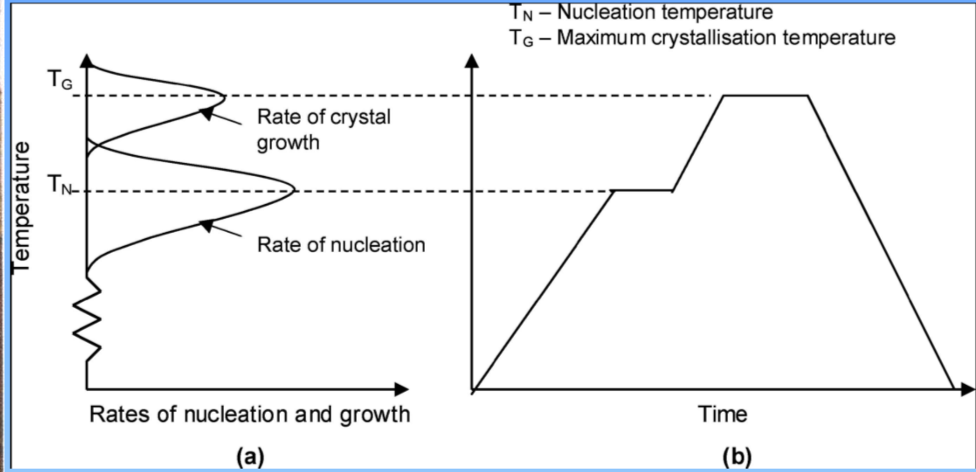


Fig. 4-8 The end of a crystallization, continuous roll furnace for production of Slagsitall



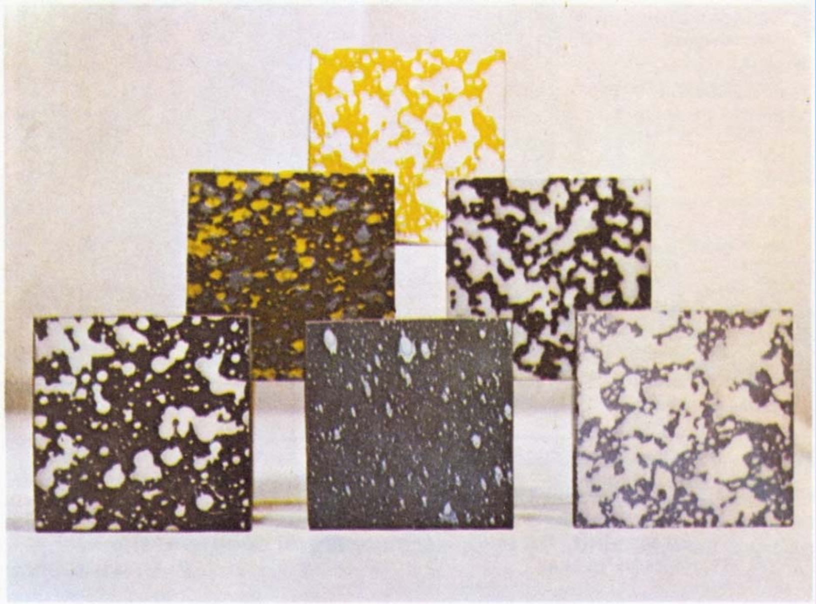


Fig. 7-38 Slagsitall tiles

- *Cheap batch composition, based on 50-60 wt % blast furnace slags;*
- *Melting at 1450-1500 °C;*
- *Rolling*
- *Crystallization treatment*

1-1.5 h nucleation at 800-850 °C

1-2 h crystal growth at 950-1000°C

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KONSTANTINOVKA – UKRAINE

2007

nter-crystallization of glass powders or grains (i.e. frits) is an alternative ospective technique for glass-ceramic production.

ges:

- ***tion of nucleants and no nucleation treatment are needed.***
- ***glasses with lower degree of homogenisation can be used.***
- ***s with complicated shapes and various sizes can be produced.***

tages:

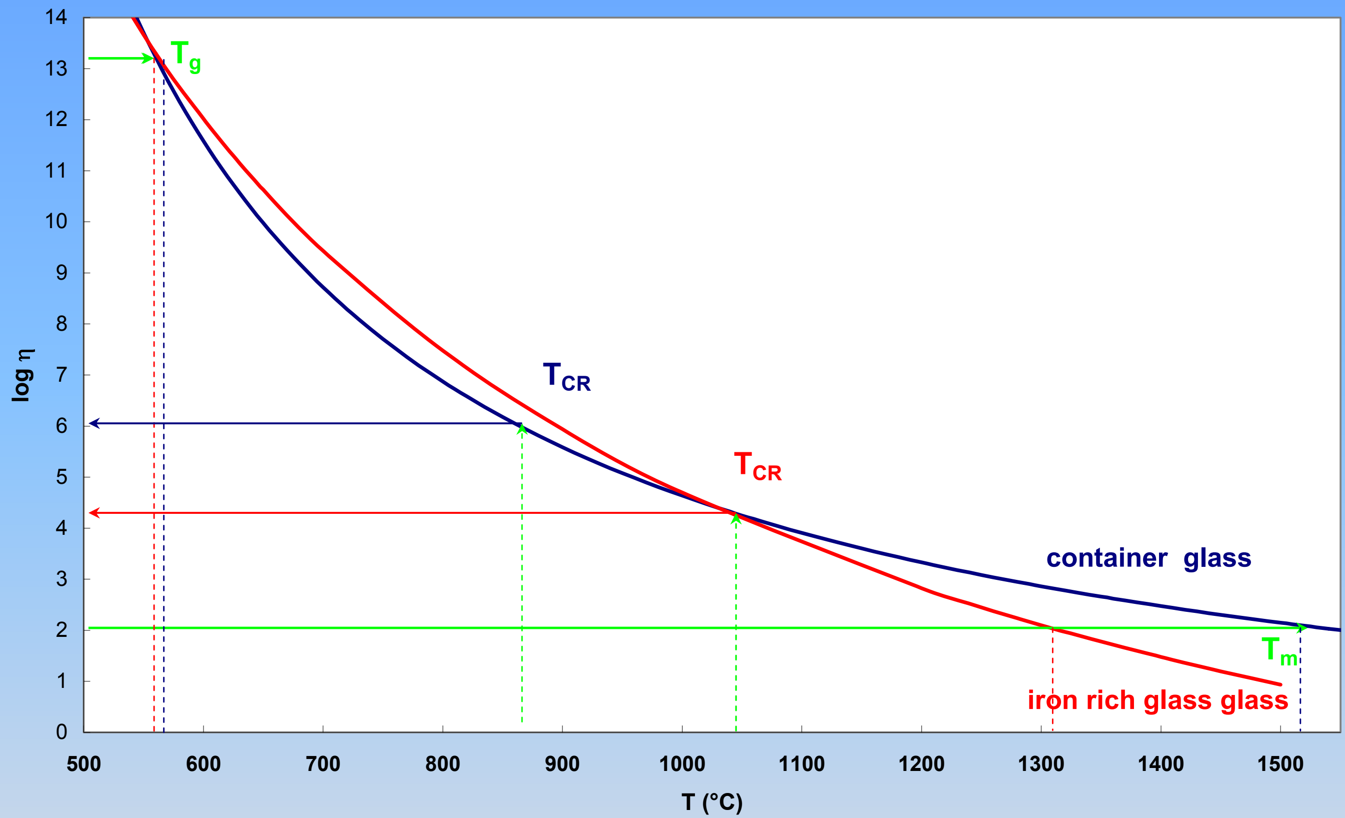
specific features of the iron-rich glasses

in the glasses is presented in Fe^{2+} and Fe^{3+} forms and the $Fe^{2+}\backslash Fe^{3+}$ ratio ds on the temperature, the melting conditions and parent glass osition.

iron oxides have limited solubility in silicate melts, resulting in a aneous liquid-liquid immiscibility which leads to high crystallization trend.

eating the glasses above the glass transformation range surface oxidation ⁺ to yield Fe^{3+} takes place. However this oxidation process can be avoid inert atmosphere.

Viscosity curves of container glass and a typical iron-rich glass from industrial wastes



age:

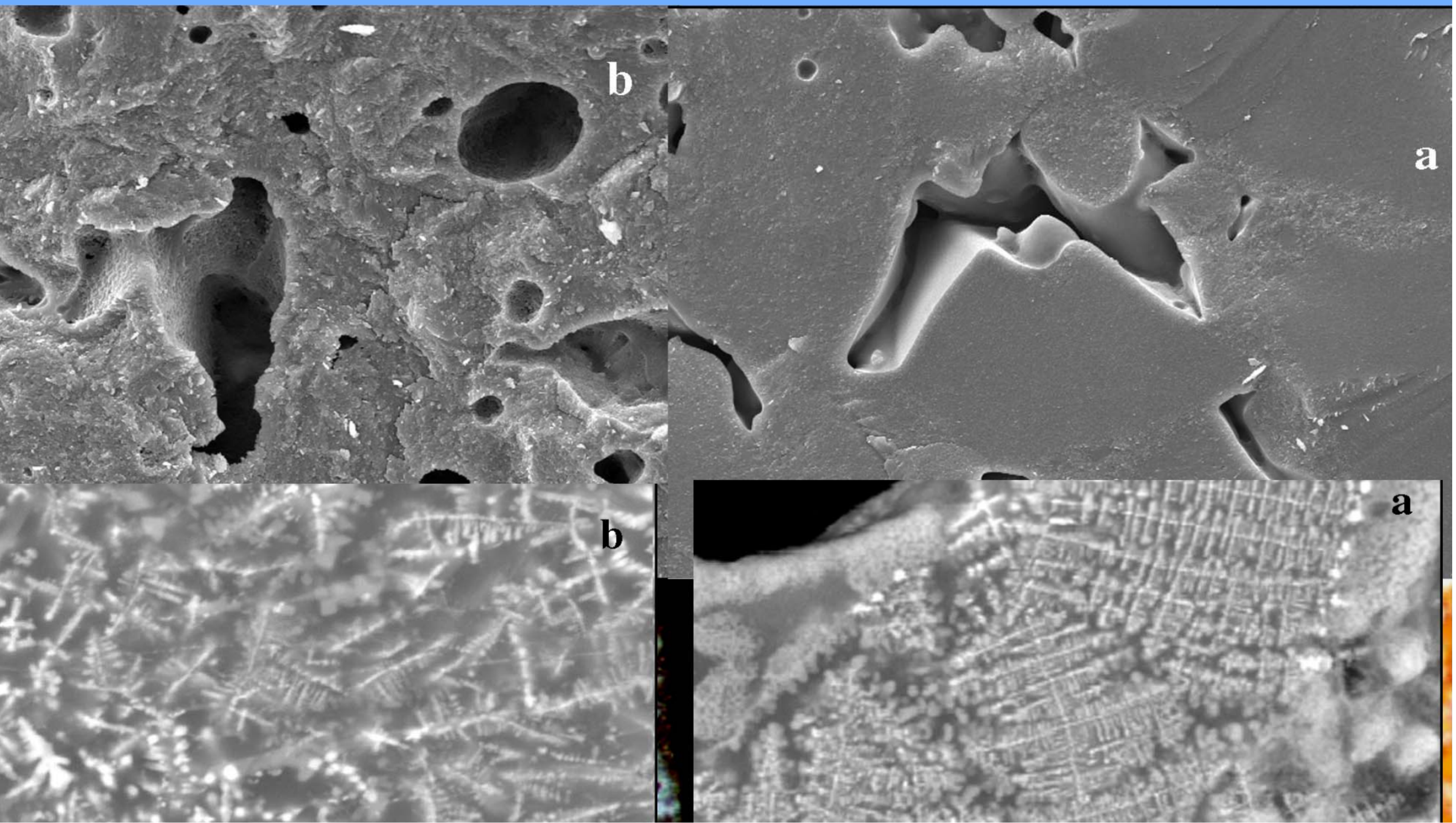
er price of the vitrification procedure;

er tendency for evaporation of heavy metals during the glass melting.

ntages:

Structure of sintered Jar iron-rich glass-ceramic

sintered in nitrogen and in air and atmospheres

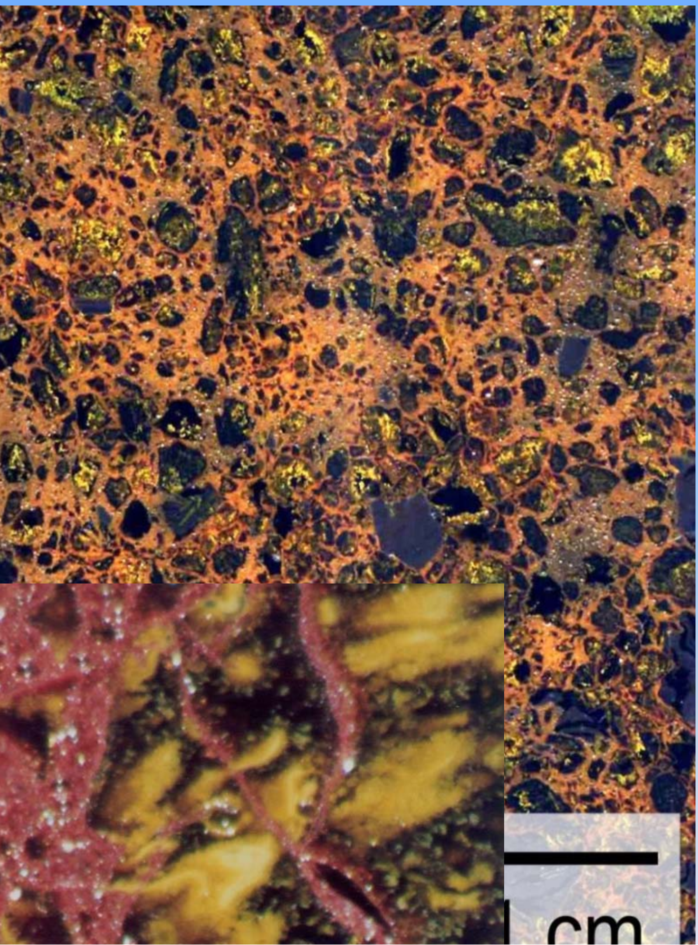


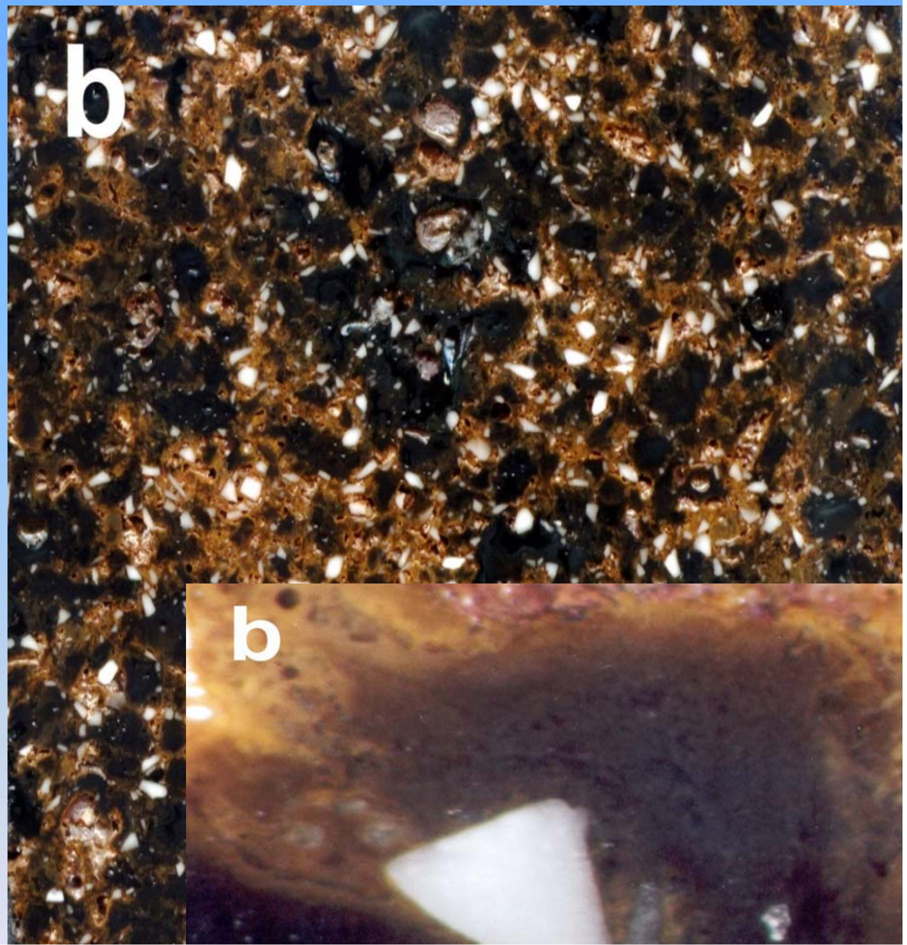
Properties of sintered iron rich glass-ceramic in air and in nitrogen atmosphere (1 h step)

	in air	In N_2
ering temperature (^oC)	1050	970
ear shrinkage (%)	11.5±0.2	12.2±0.3
ding strength (MPa)	84±8	126±6
ng' Modulus (GPa)	78±4	81±4

G-Goe glass-ceramic (a) and G-Flo composite (b)

(sintering 30-60 min at 1010-1030 ^{o}C)





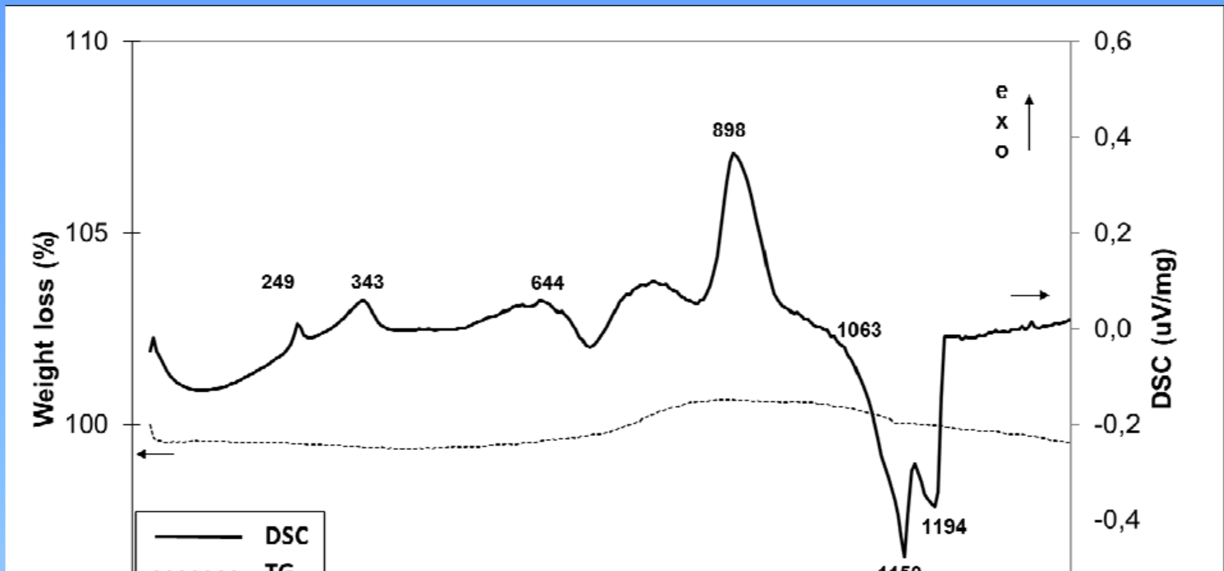
Properties of sintered iron rich glass-ceramic from frits (G-Jar) , Neoparies (N) and granites (G)

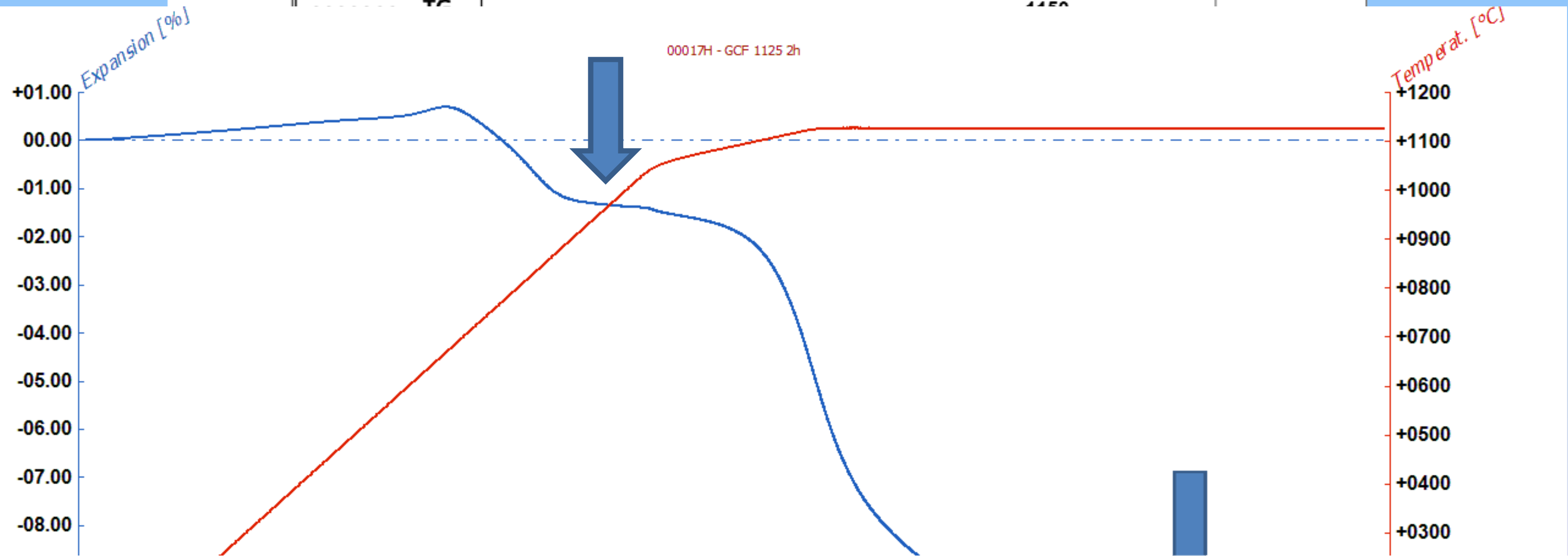
Properties	*G-Jar*	*N*	*G*
Density (g/cm^3)	*2.8-2.9*	*2.7*	*2.6-2.8*
nding strength (Mpa)	*72±7*	*55*	*12-20*
lulus of Elasticity (GPa)	*48±4*	*85*	*35-55*
Mooh's hardness	*6*	*6.5*	*4.5-6.5*
nal expansion ($*10^{-7} K^{-1}$)	*65-70*	*65*	*65-90*

MSWA iron- rich glass (as it is melting for 1 h at 1400 ºC)

	GF	GF-ox
SiO_2	38.2	39.9
TiO_2	1.4	1.5
Al_2O_3	8.7	9.1
Fe_2O_3	0.8	5.4
FeO	8.8	-
CaO	30.3	31.7
MgO	6.0	6.3
CuO	0.7	0.7
MnO	0.2	0.2
ZnO	0.4	0.4
PbO	0.1	0.1

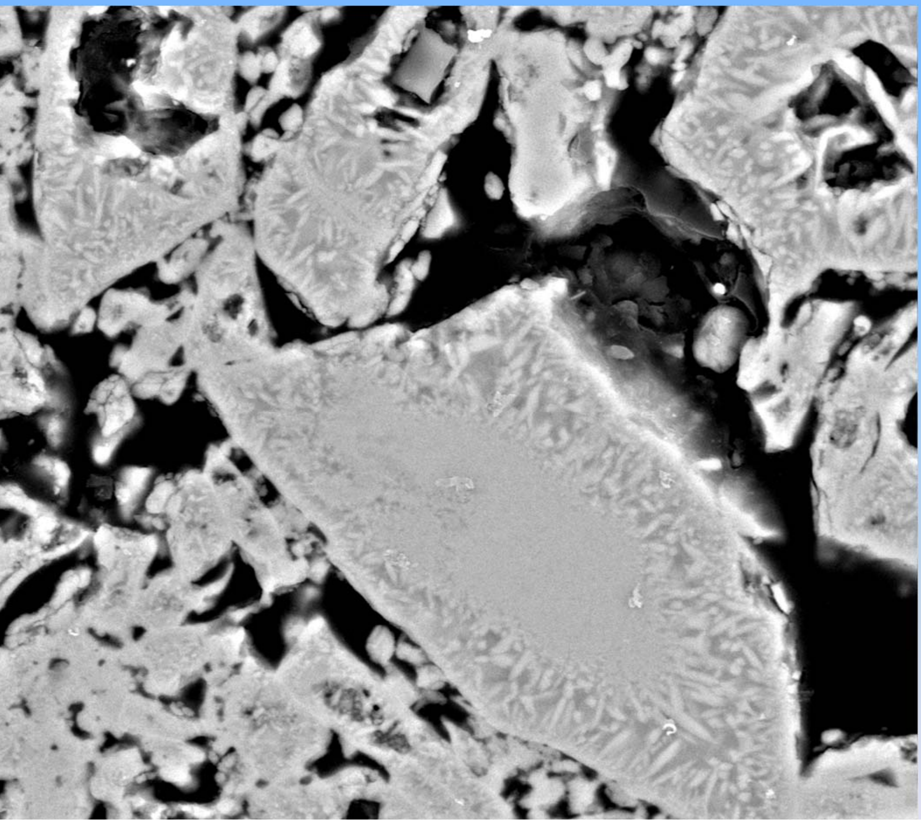
Sinter-crystallization of sintered MSWA glass-ceramic

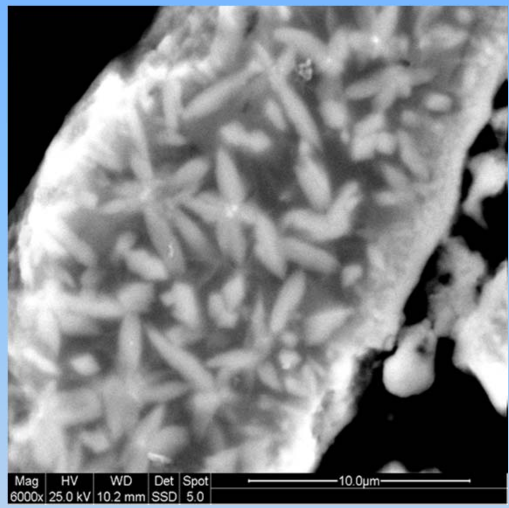


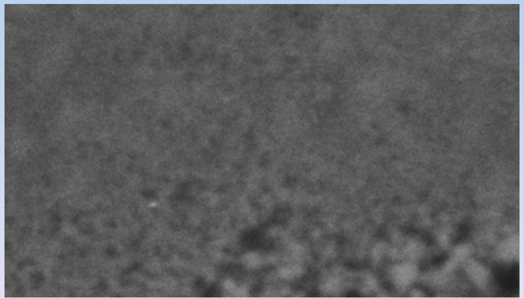


Structure of sintered G-MSWA glass-ceramic

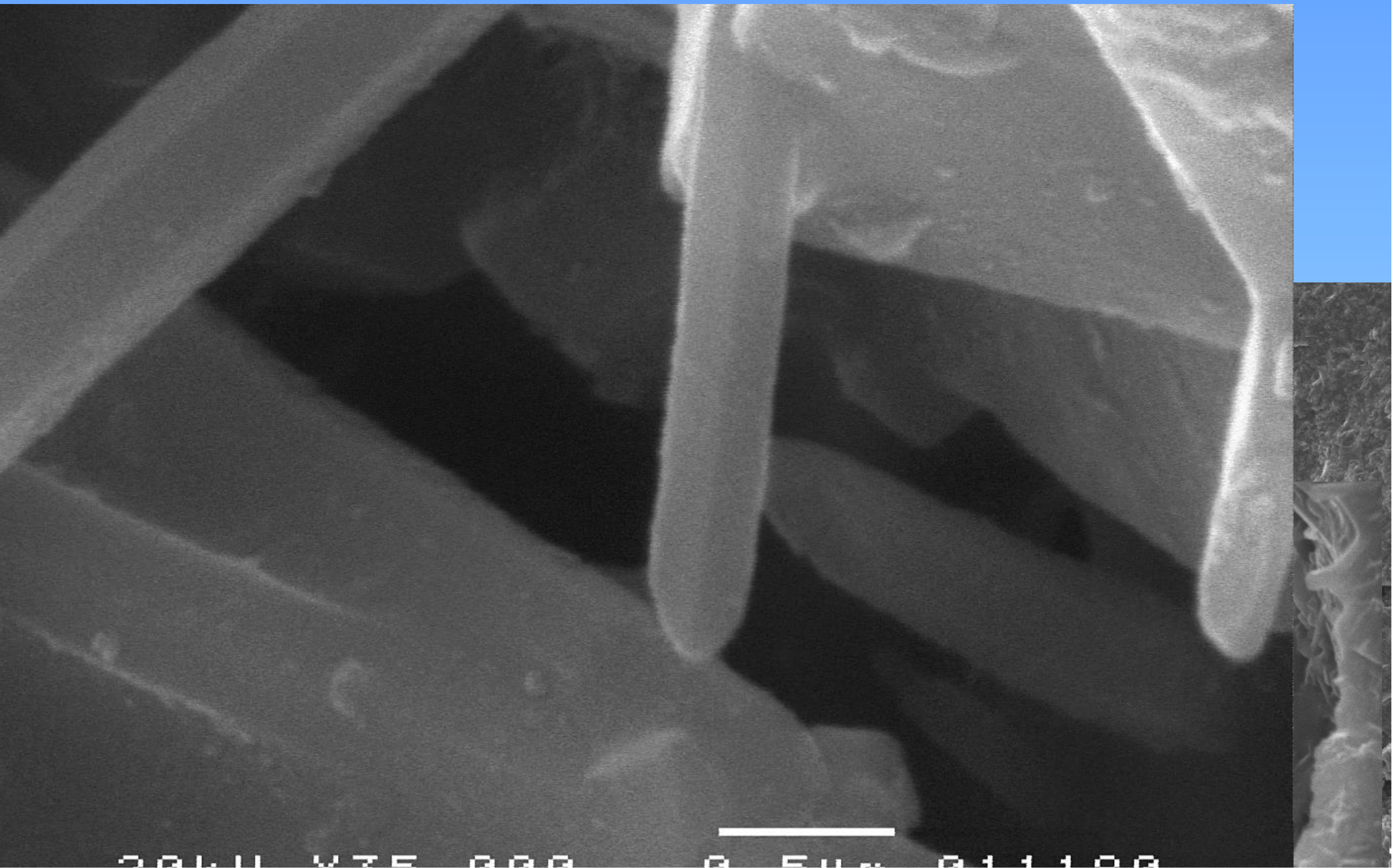
(1 h at 950 ◦C)







Structure of sintered MSWA glass-ceramic

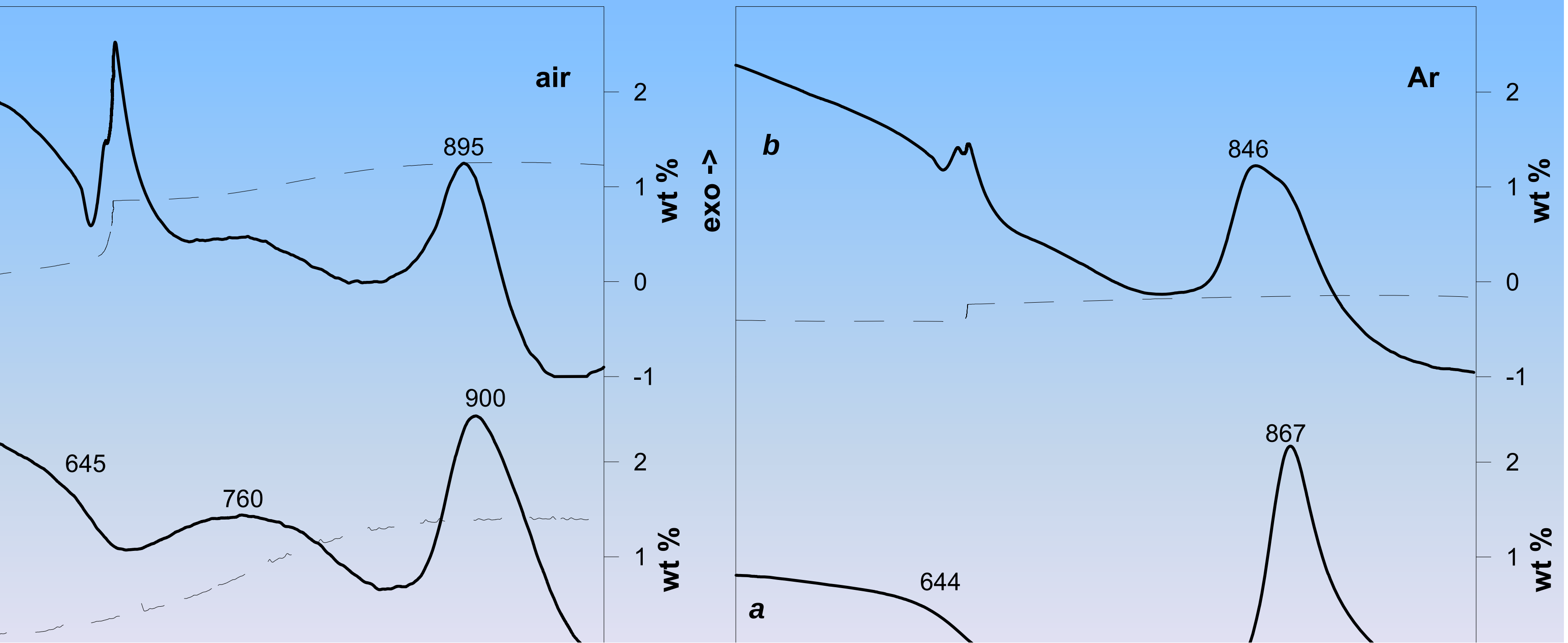


DTA traces without (a) and with (b) nucleation step

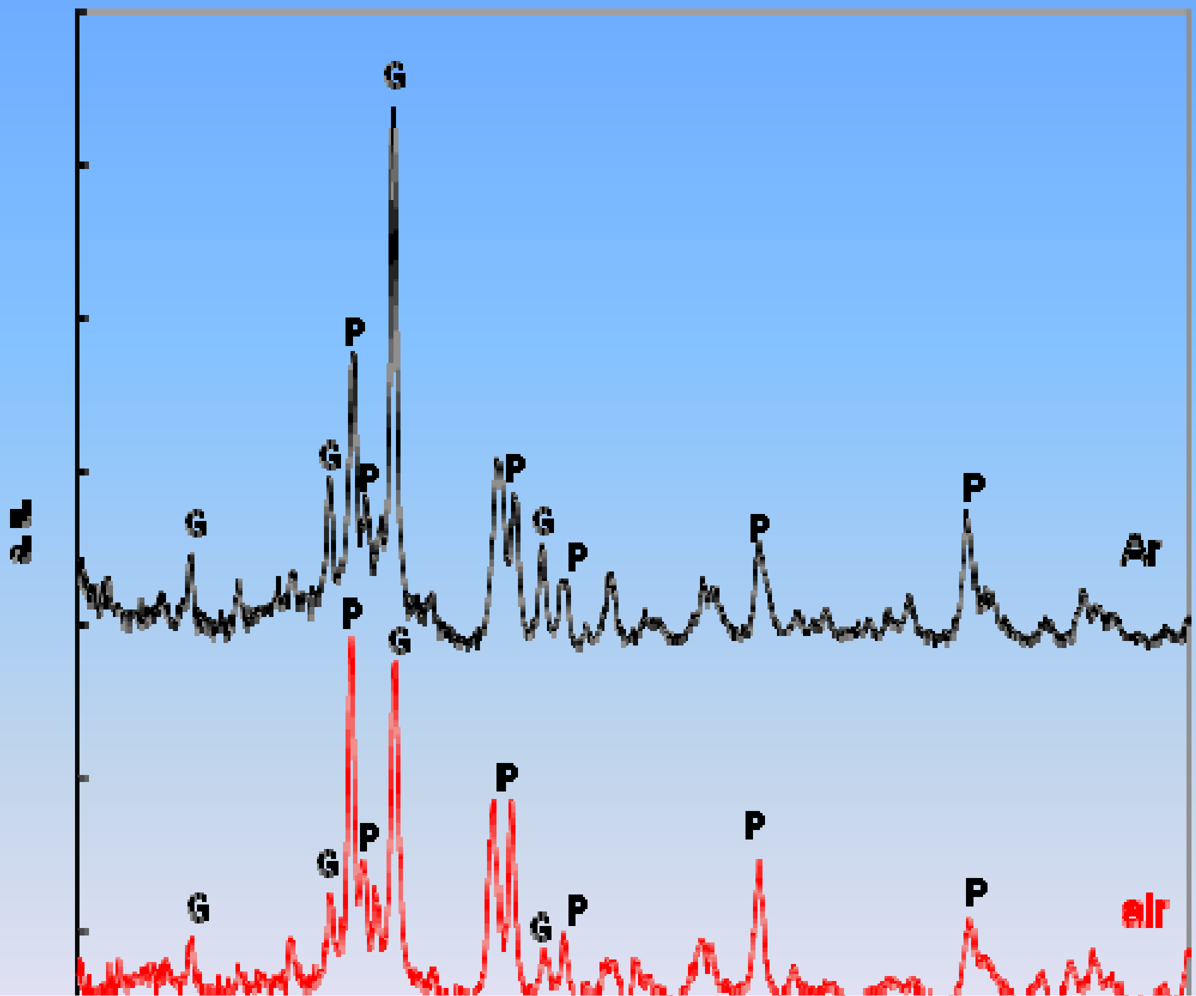
(>125 µm)

in

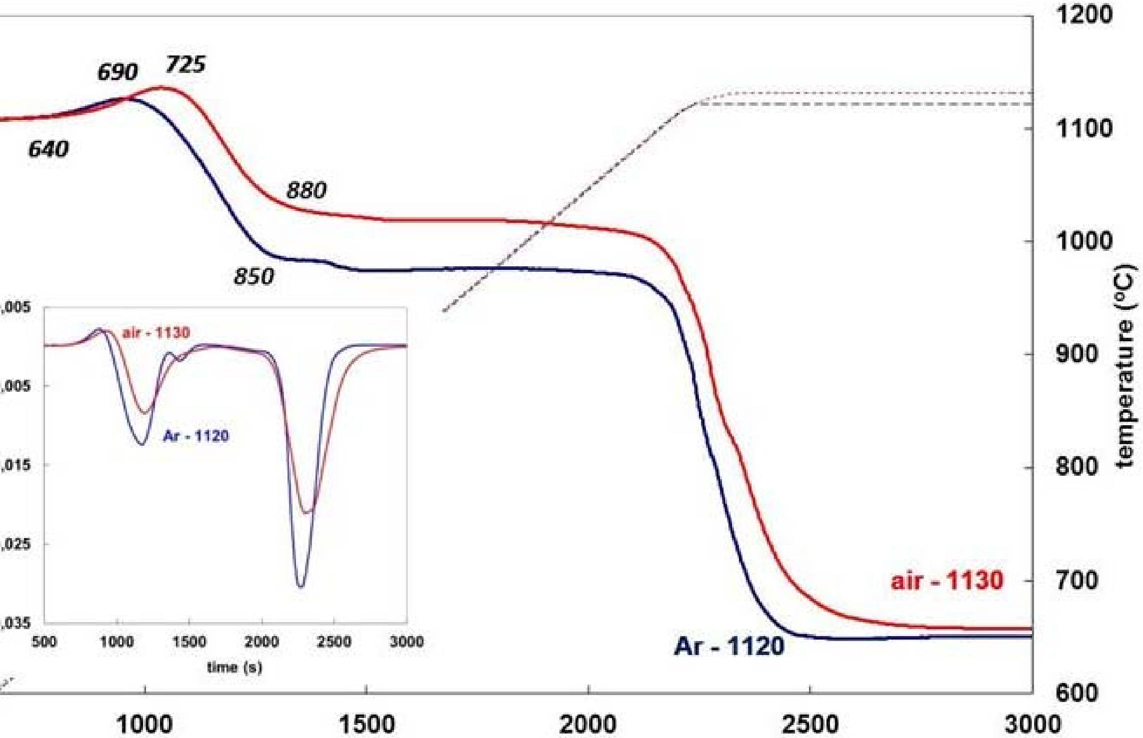
air *argon*

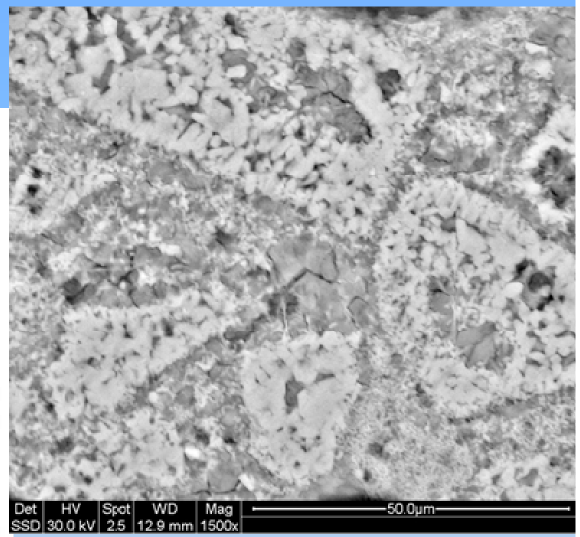


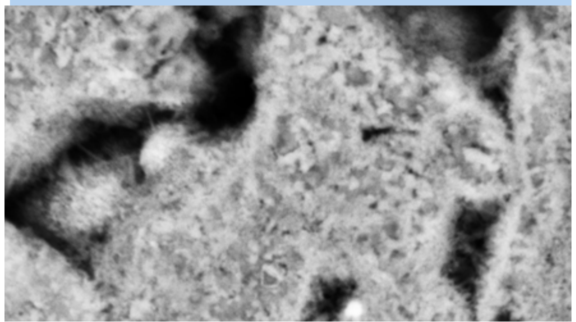
D results for MSWA glass-ceramics in air and argon atmospheres after



ification results and structure for samples, obtained in air (1 h holding at 1130^{o}C) and in argon flux (1 h holding at 1120^{o}C).





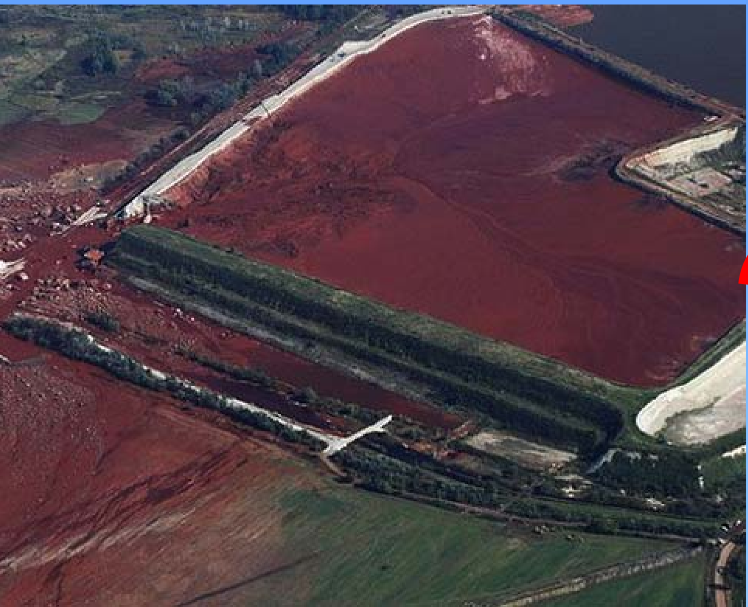


lusions

possibility to use “as it is” vitrified MSWA for synthesize of cheap sintered erial with very fine crystalline structure and short thermal cycle near the ectic temperature is demonstrate.

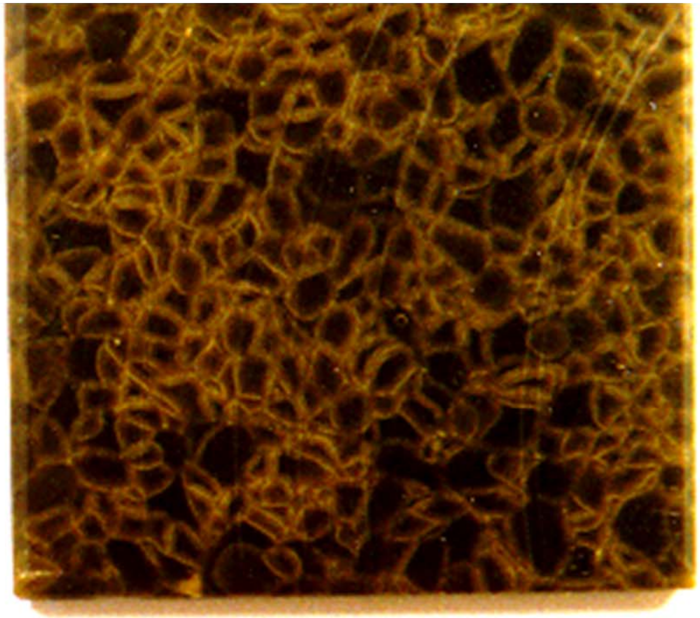
investigated glass powders are characterized with high crystallization trend formation of pyroxene and melilite solid solutions at 850-900ºC. In air osphere, after Fe^{2+} oxidation, the phase formation leads to oxene/melilite ratio of about 2, while in inert atmosphere no oxidation es out and the ratio pyroxene/melilite notably decreases.

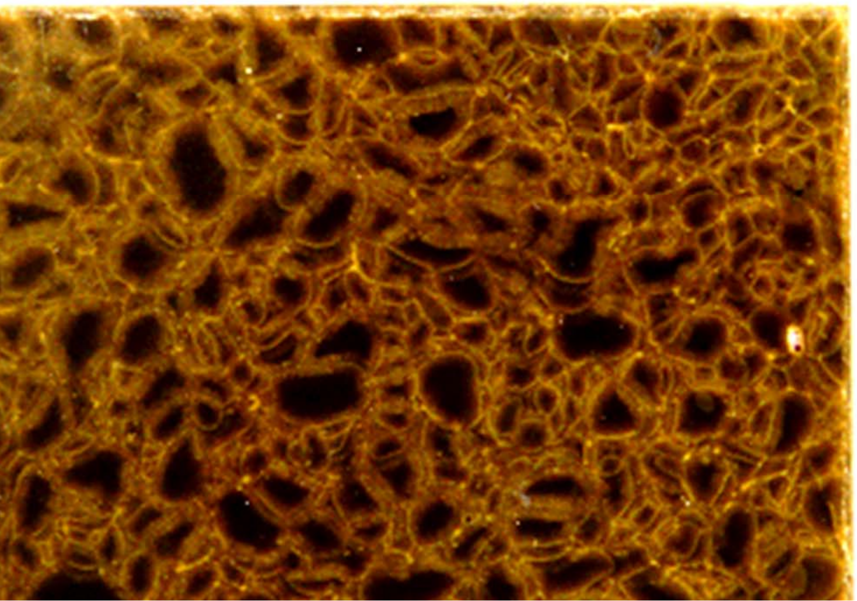
intensive phase formation inhibits the densification at low temperatures in n atmospheres. However, after increasing of the sintering temperature up to 0-1130ºC secondary densification caries out, resulting in material with zero er absorption, low closed porosity and high crystallinity.

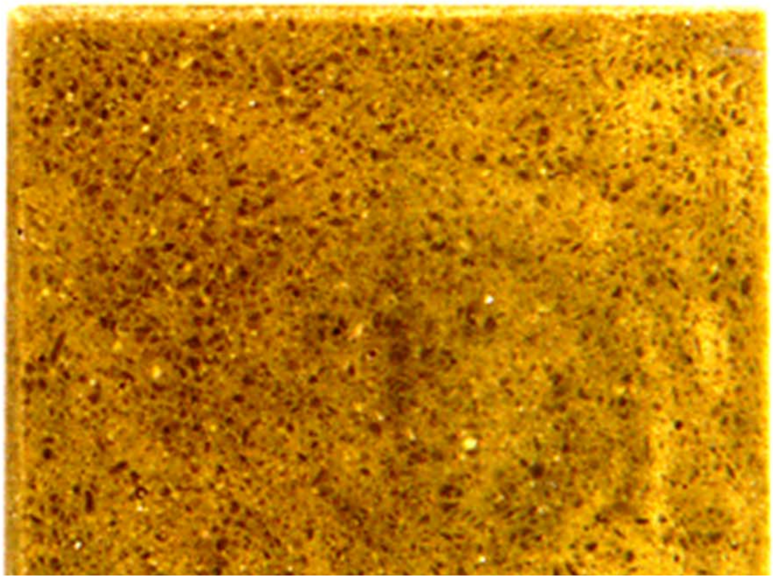



To Gates
1 - 11
Women

Sintered glass-ceramic **G-60 MSWA**







Sintered glass-ceramics from MSW fly ash

STRUCTURE OF SINTERED GRANITE-LIKE GLASS-CERAMIC (G-60)