Kaolins for large slabs

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Large slab production requirements

Conventional porcelain stoneware bodies can be used to fulfill the minimum requirements for large slab production given by OEMs , such as :

▪ Green MOR	≥ 8 kg/cm²
▪ Dry MOR	≥ 30 kg/cm²
▪ Shrinkage	< 7.5-8.0 %
▪ Water absorption	<0.02%
▪ Pyroplastic deformation	≤3.0 mm
▪ Thermal expansion coeff. (50-400°C)	≤72 10-7 °C

However it turns out some additional features are needed to achieve the highest performances.

- Additional requirements :

- Flexibility in green and dry : to absorb the deformation/stresses on the production line

- Low residual thermal stress after firing to prevent catastrophic failures

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Kaolins for superwhite slabs

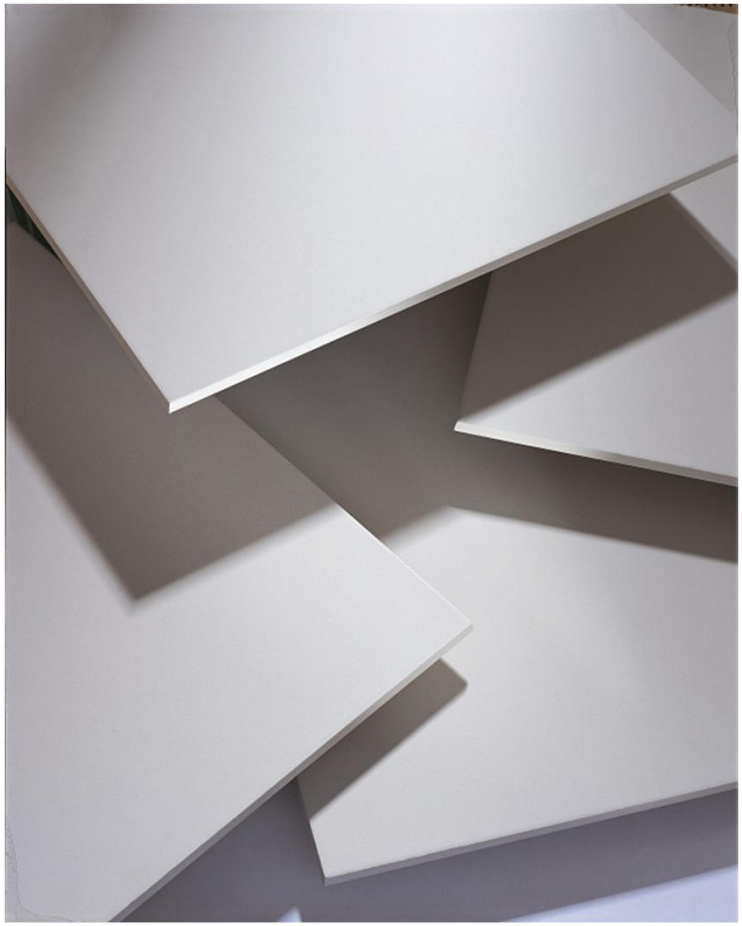
The kaolins used for white and superwhite slabs (L*>88) must have :

- a high pressability (good compaction - low expansion after pressing) to be used as the main plastic component (without ball clay), together with minerals like bentonite and/or organic additives .

- enough “flexibility” and modulus of rupture to absorb the handling stresses on the production line before firing.

- a high whiteness thanks to low chromophores (Fe2O3 and TiO2 mainly)

- a good cleanliness, to prevent colored spots appearing on very white body.



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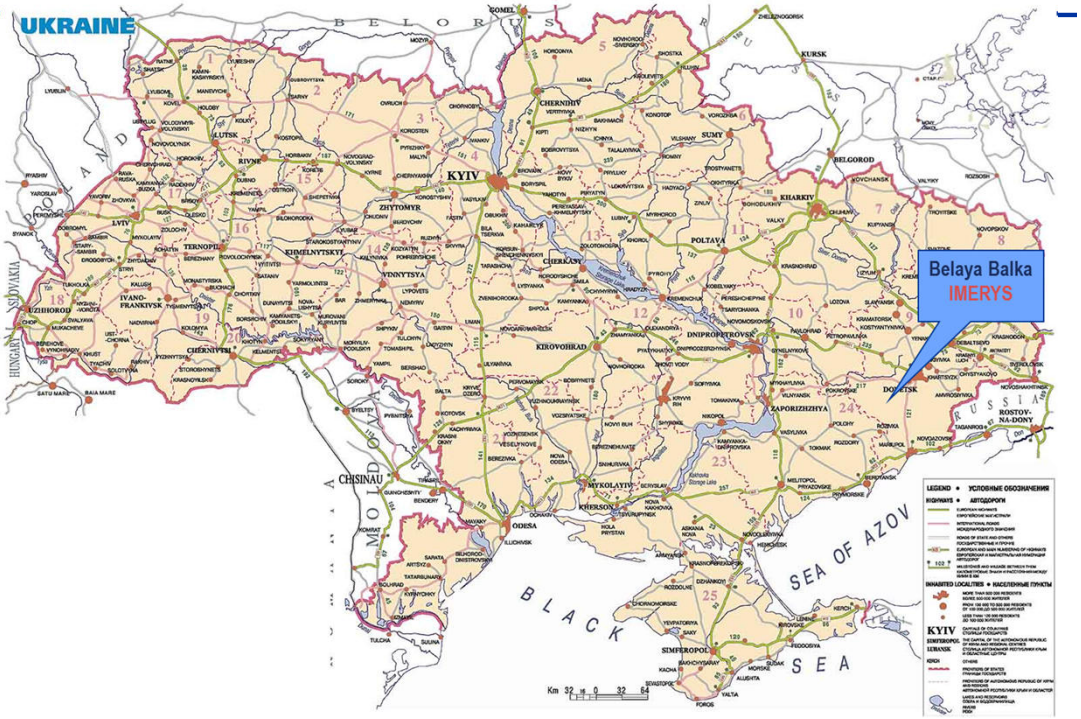
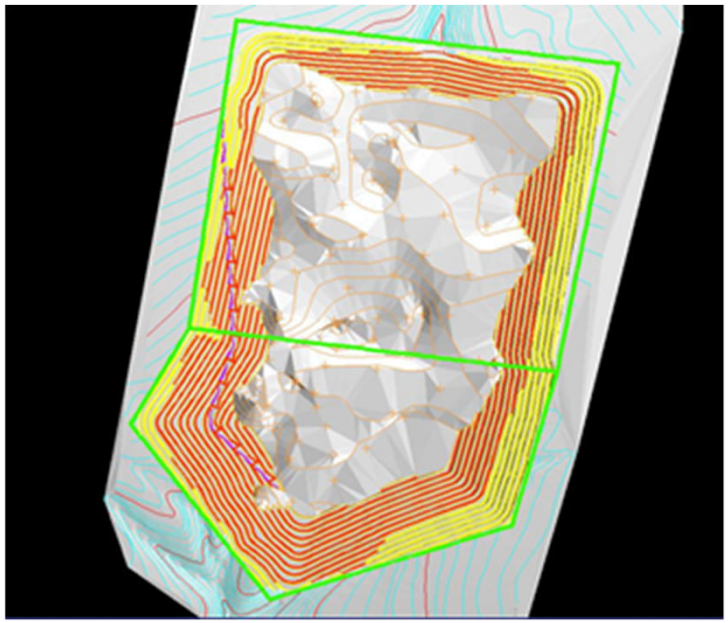
Kaoshine BB30, a new refined kaolin

Donbass Keramika is located in the Donbass basin, east Ukraine

Extraction of a secondary raw kaolin matrix known as KBB.

Large reserves of the kaolin matrix are available to produce the refined kaolin.





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Kaoshine BB30, a new refined kaolin

KaoShine BB30 is a wet refined kaolin from Donbass basin - Ukraine. It is the results of processing KBB matrix from the Belaya Blaka deposit.

Transportation from the quarry to the refining plant

KaoShine BB30

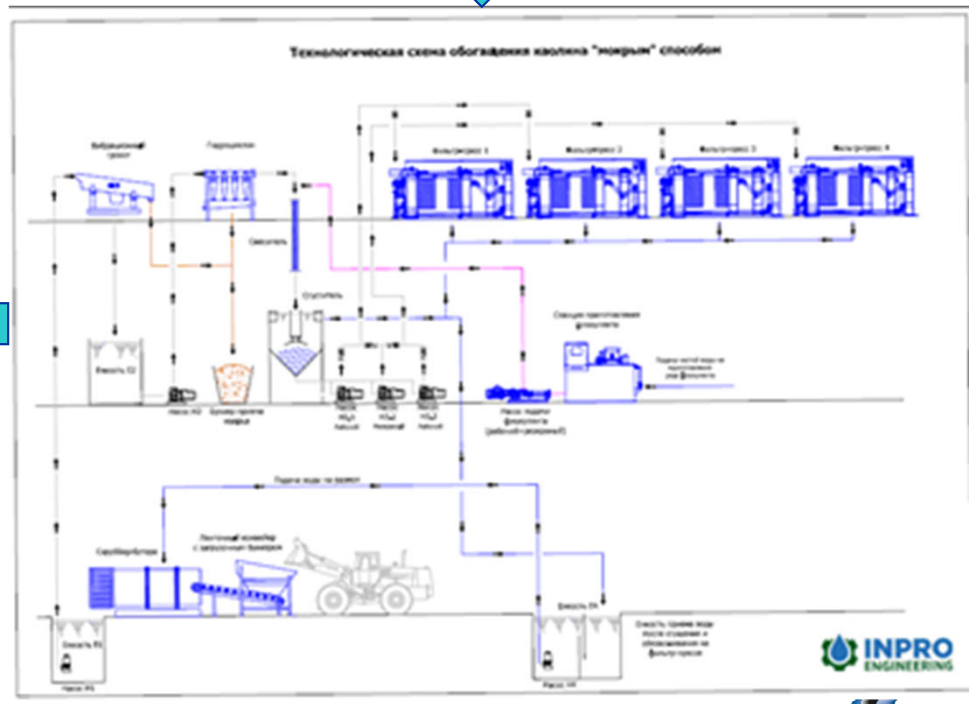
APPLICATION(S)
Tableware, Tiles Glaze

TYPICAL PROPERTIES

CHEMICAL ANALYSIS (%)	Value
SiO_2	47.1
Al_2O_3	37.6
Fe_2O_3	0.35
TiO_2	0.56
K_2O	0.4
Na_2O	<0.1
CaO	0.4
MgO	<0.1
L.O.I.	13.4

MINERALOGICAL ANALYSIS (%)
Kaolinite, Quartz, Anatase

PARTICLE SIZE ANALYSIS - Sedigraph (cumulative mass %)	
< 10 µm	95
< 5 µm	87
< 2 µm	70



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Kaolin comparison in a body formulation

Several plastic and white kaolins were selected and tested in comparison with Kaoshine BB30 :

Name	Kaoshine BB30	CR Super	BIP	Kaoshine PL30	Grolleg	Standard Porcelain	Kaoshine MO50	Kaolin B
Provider	Imerys	Imerys	Imerys	Imerys	Imerys	Imerys	Imerys	Other
Origin	Ukraine	Brazil	France	France	UK	UK	Italy	
SiO2	47.1	46.4	49.6	46.3	48.6	48.2	48.2	52.5
Al2O3	37.8	38.6	35.6	38	36	36.9	37.8	33.6
Fe2O3	0.3	0.57	0.4	0.43	0.83	0.71	0.65	0.7
TiO2	0.6	0.67	0.01	0.33	0.04	0.04	0.67	0.43
CaO	0.17	0	0.11	0.05	0.07	0.1	0.12	0.13
MgO	0	0	0.04	0.05	0.17	0.3	0.08	0.39
Na2O	0	0.06	0.06	0	0.06	0.07	0.02	0
K2O	0.38	0.03	2.02	0.98	1.92	1.98	0.16	0.93
LOI	13.3	14.0	11.4	13.3	12.5	12.2	13.2	11.6
wt% >10 µm	5	1	17	0.5	3	1.2	2	3
wt%<2 µm	68.5	81.8	44	64.5	64	69.4	77.6	58.6
wt%<1 µm	53	60	31	44.4	50	54.2	55.1	36
Quartz	2	0.4	6	2	1	1	4	11
Kaolinite	95	99	71	88	82	84	91	79
Muscovite	*		***	**	**	**	*	**
Mg, Ca Smectite			*		*	*	**	***
K feldspar					**	**		*
Anatase	tr	0.6					0.5	0.4
Rutile							0.2	tr

	% (dry)
Floated feldspar	65
Silica sand	3
Kaolin	30
Zircon	2
Total	100,0
TPPS	0,4
Water	50
milling time (min)	22
Pressing Force (kg/cm²)	450

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Results : green state

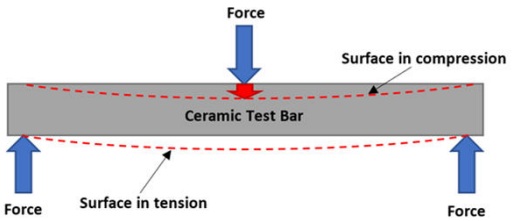
After milling in rapido mill for 22 minutes, the compositions were dried and granulated with 6% water.

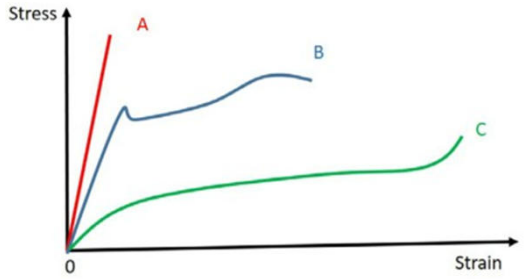
10 bars (10x2 cm) were pressed at a pressure of 450 kg/cm² .

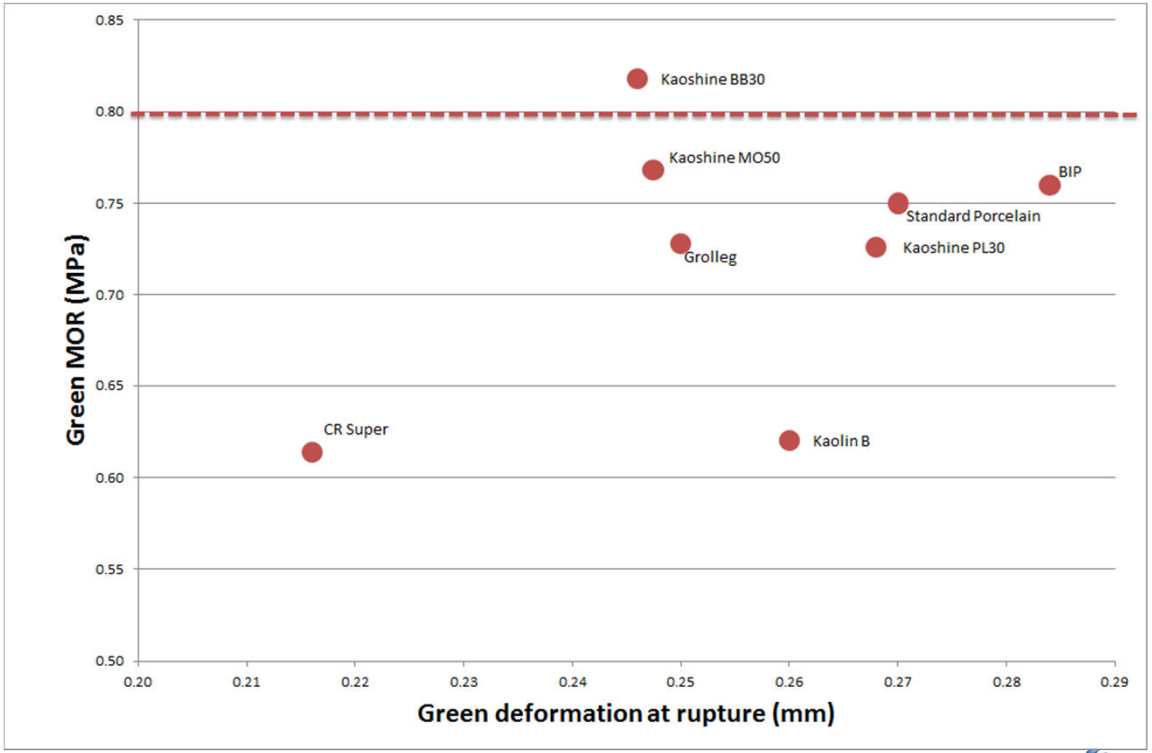
Before drying, 5 bars were measured by 3 point bending test to obtain modulus of rupture (MOR) and deformation at rupture

Green MOR and deformation are not correlated.

The best kaolins are Kaoshine BB30 for MOR and BIP for deformation.







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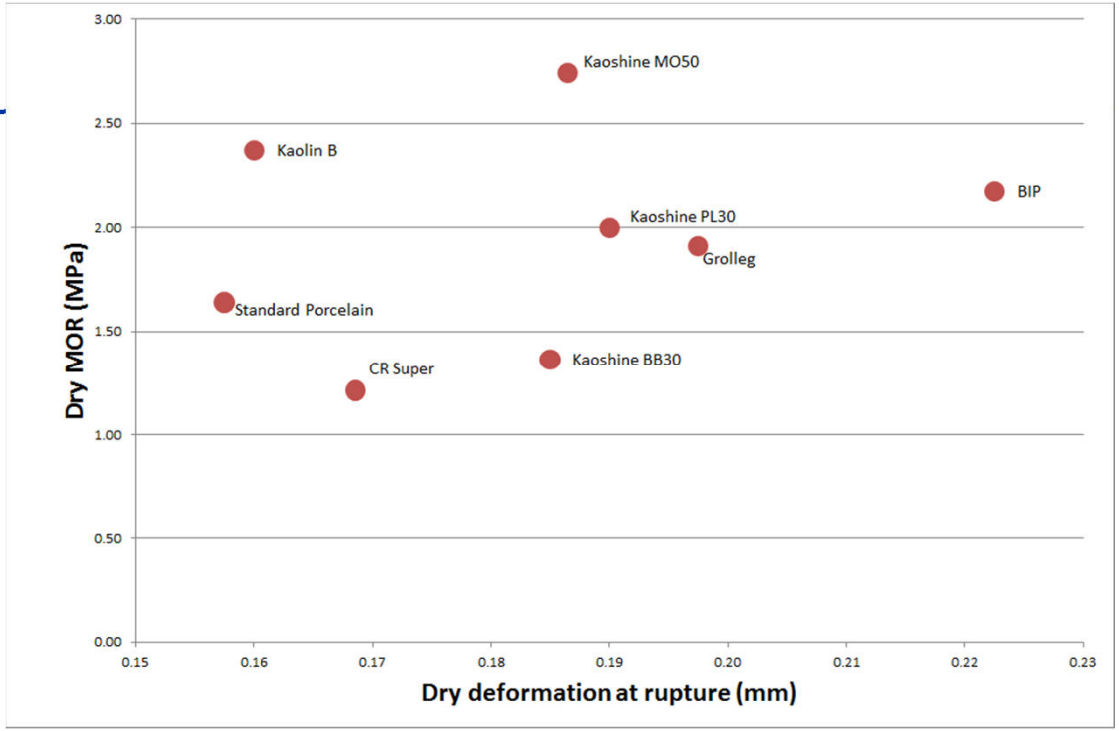
Results : dry state

After drying, Modulus of rupture (MOR) , bulk density, and deformation at rupture were measured on 5 bars.

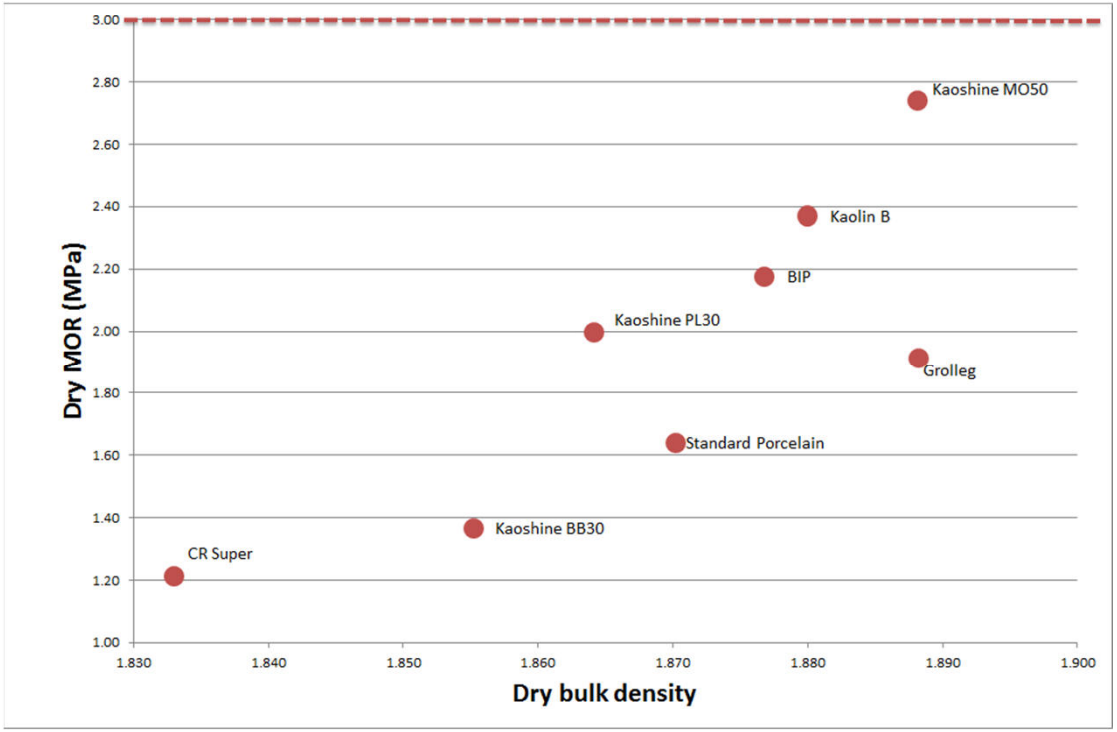
Kaolins containing smectites have a high MOR but lower deformation => more “brittle” behaviour



The dry bulk density is quite low as there is no added plasticizers in these compositions.

Kaoshine MO50 has the best compromise of green and dry performance.

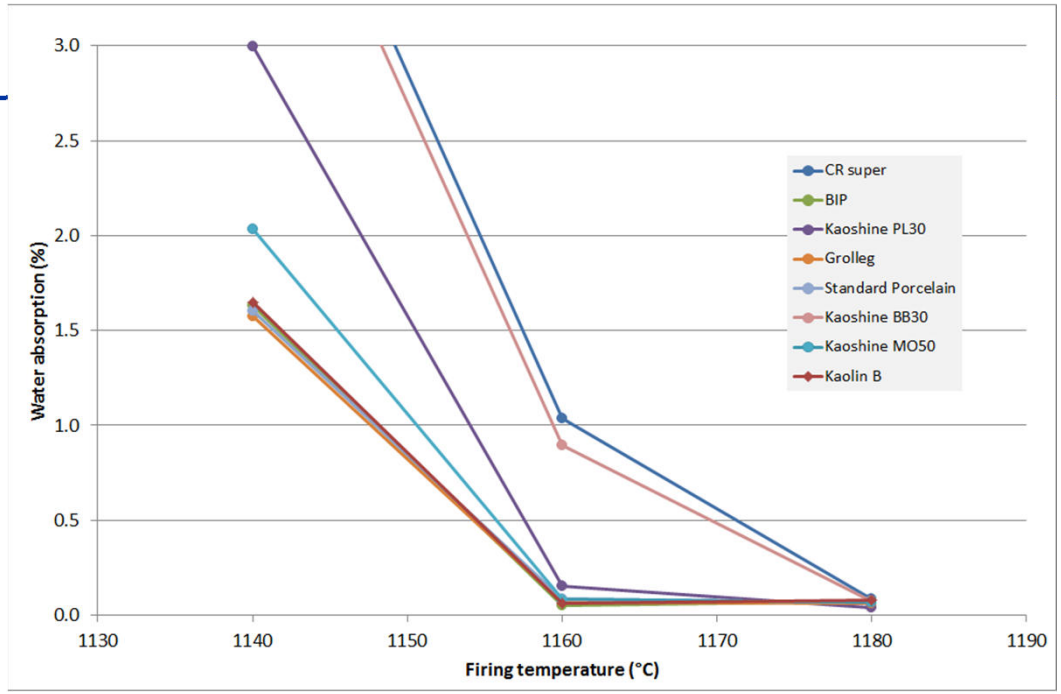
Kaoshine BB30 lacks some dry performances and can be associated with smectite bearing clays like FMT.

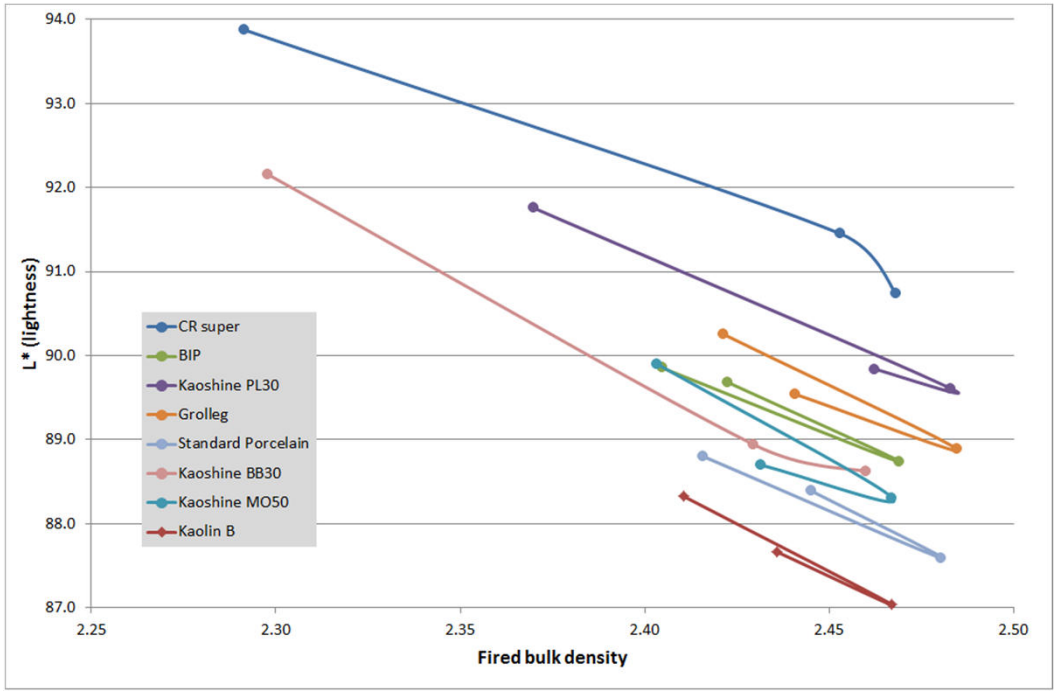


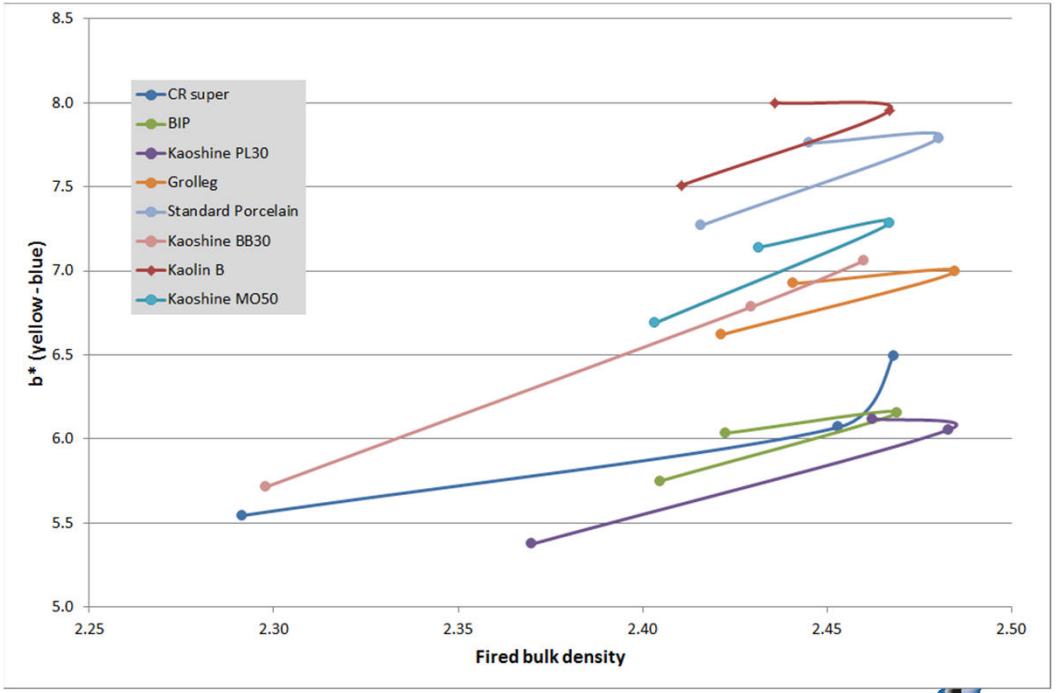
Results : fired state

Finally discs were fired in a fast firing lab electric kiln at various temperature to compare fusibility (water absorption) , densification (Shrinkage, bulk density) and whiteness.

CR super and Kaoshine BB30 must be fired slightly higher temperature to reach the full densification due to a higher Kaolinite content.







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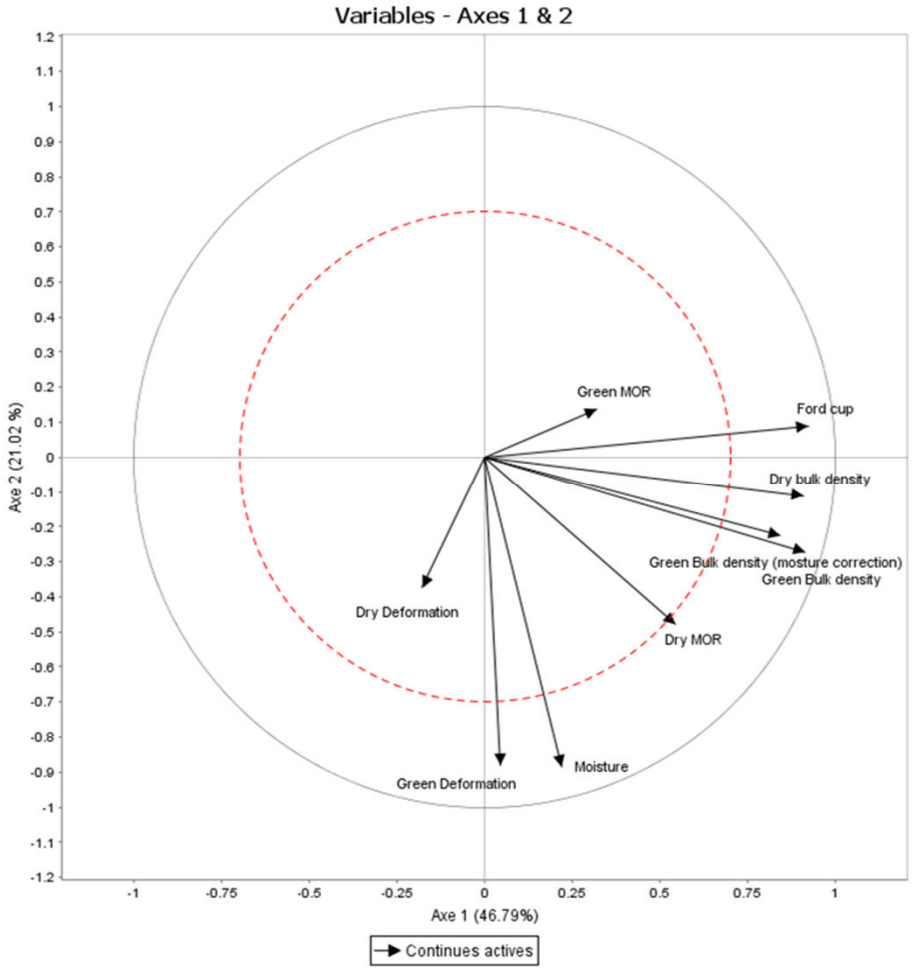
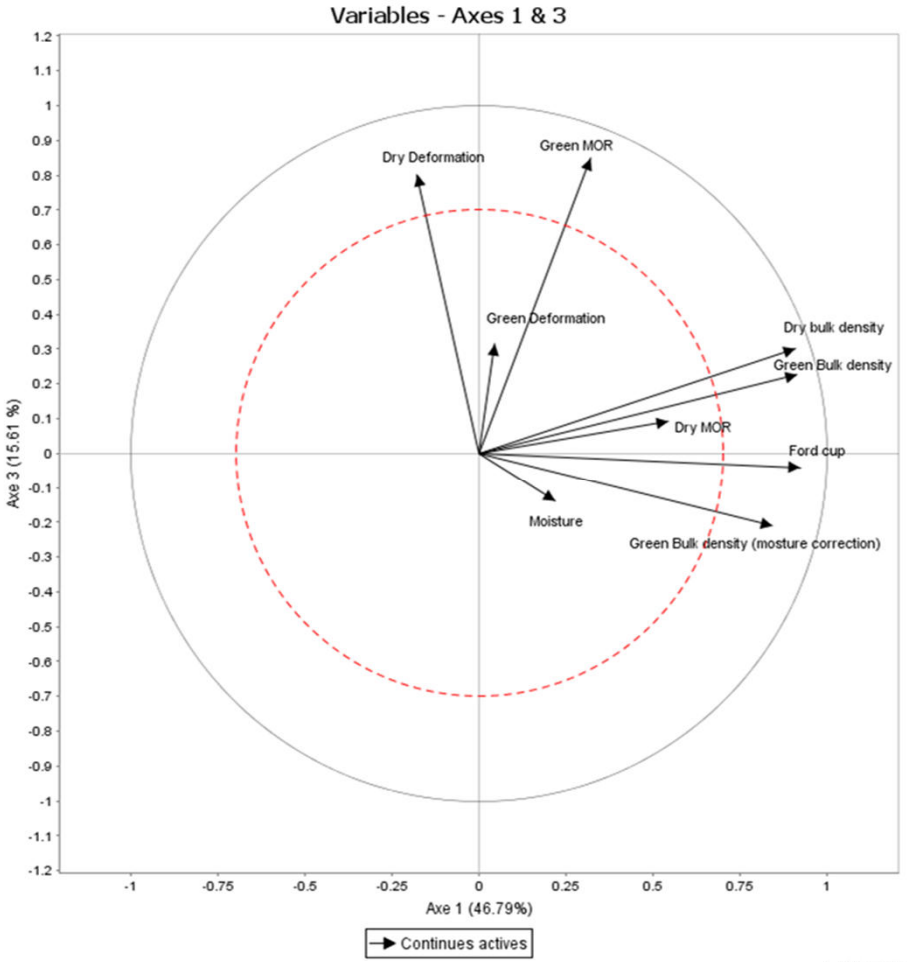
Principal component analysis

Principal component analysis is a statistical method used to analyze large datasets of variables or to find relationships between variables.

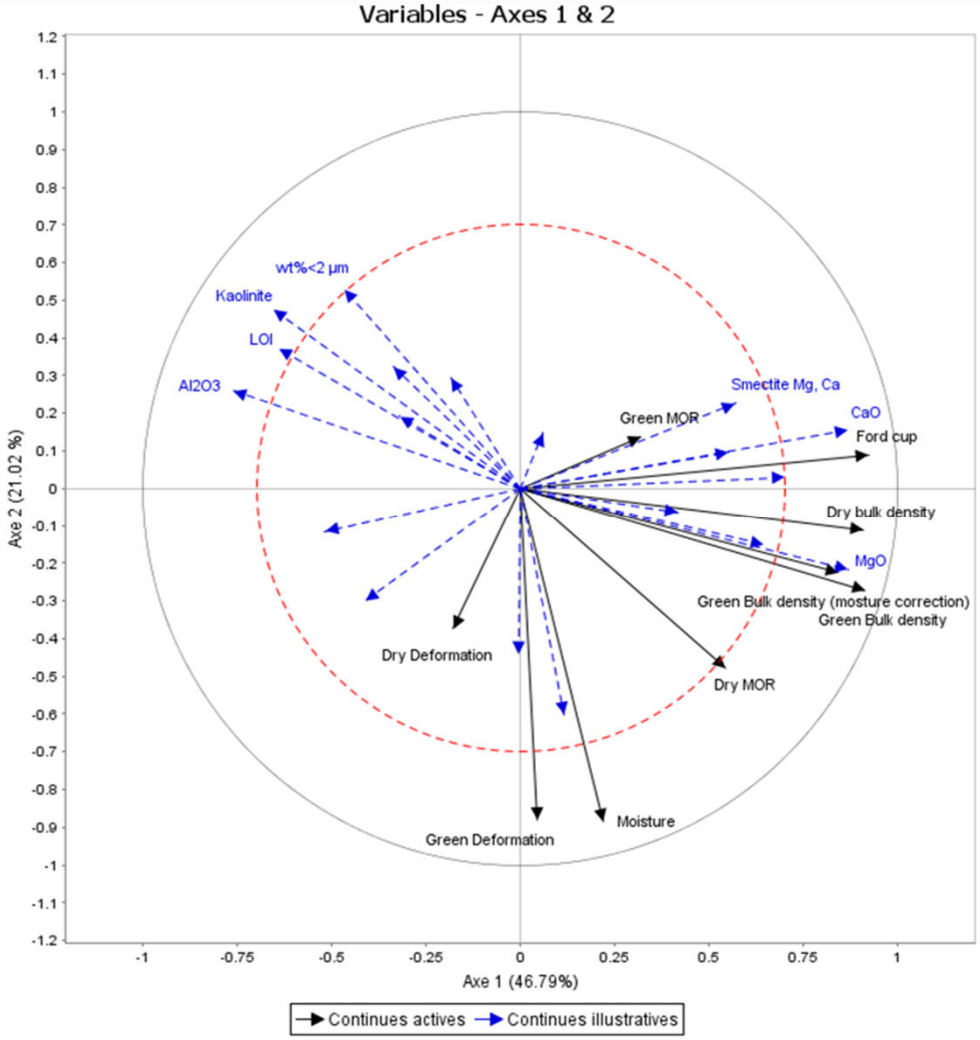
It helps minimizing the number of variables while keeping the largest amount of variance (i.e. “information”).

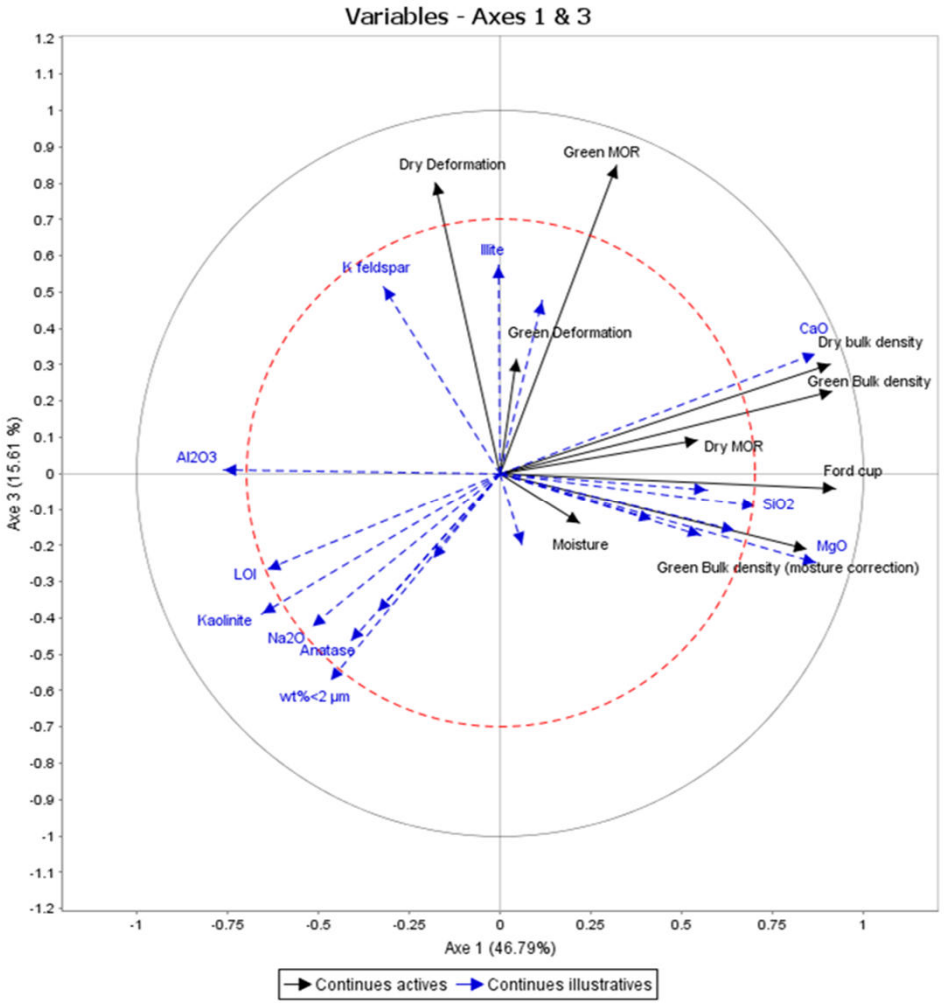
The below graphs display 83 % of the total variance of the active variables. (fired data not included here)





Principal component analysis





Kaolins with smectite have a better compaction behaviour as opposed to kaolinite rich

However kaolinite content is necessary to obtain the highest values of whiteness as well as mechanical behaviour during and after firing (fired MOR and pyroplasticity)

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Conclusions

All kaolins do not offer the right balance of green / dry / fired performances :

High kaolinite content products from Donbass like Kaoshine BB30 can be used in white slab production, provided the compaction is improved by plasticizing minerals.

Kaolin products having a smectite content are usable directly to replace most of the clay content used in the darker body compositions.

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