# Imerys raw material solutions for energy savings

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# Solutions for energy savings

## Introduction

## Fluximax

## Ceraflash



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# Energy saving through a clever choice of raw materials

Thermal energy is the main source of energy needed in tile and slab manufacturing. It is used mainly during the firing stage to heat up the materials and fuel the chemical reactions. It amounts to about 50% of the energy consumed on the overall process.

To reduce the energy needed in the firing of porcelain stoneware, the simple solution is usually to reduce either the firing temperature or the firing cycle time by using well known solutions such as :

- Ca and Mg minerals to create eutectics => Talc, Wollastonite, Magnesite …

- High fusibility minerals => Lithium bearing feldspars like B44

Working on the reduction of the thermal energy needed by the ceramic body during firing is another strategy to reduce the overall consumption.

- ➔ Use of lower decomposition energy minerals
- ➔ Use of low Loss Of Ignition (LOI) minerals
- ➔ Increase the crystalline phase generation

*Source : Estimation of the heat of reaction in traditional ceramic compositions*
*S. Ferrer; A. Mezquita; M.P. Gomez-Tena; C. Machi; E. Monfort*



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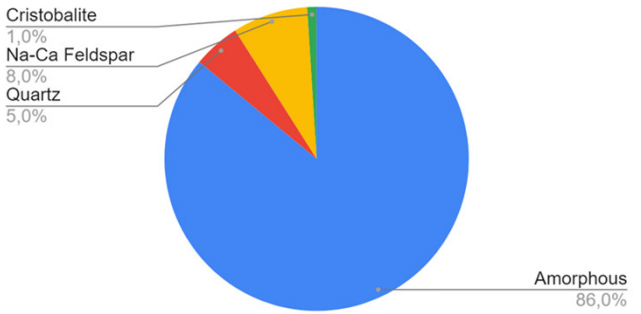
# Fluximax

Perlite is a naturally occurring volcanic rock formed from siliceous lava/ash. It is composed of a large fraction of amorphous phase, conveying a quick and homogeneous melting during ceramic firing.

Origin : Milos, Greece

| CHEMICAL COMPOSITION (%) | | Value |
|---|---|---|
| $SiO_2$ | | 74.0 |
| $Al_2O_3$ | | 13.0 |
| $Fe_2O_3$ | | 1.0 |
| $K_2O$ | | 3.5 |
| $Na_2O$ | | 4.5 |
| CaO | | 1.4 |
| MgO | | 0.25 |
| L.O.I. | Fluximax 0,3-0,075<br>Fluximax 2-0W | 1.6<br>2.6 |

| PHYSICAL CHARACTERISTICS | | |
|---|---|---|
| Grain size | Fluximax 0,3-0,075<br>Fluximax 2-0W | 0.3/0.075 mm<br>2/0 mm |
| Loose Bulk Density | Fluximax 0,3-0,075<br>Fluximax 2-0W | 1100 kg/m$^3$<br>1050 kg/m$^3$ |
| Moisture content | Fluximax 0,3-0,075<br>Fluximax 2-0W | 0.5%<br>8.0% |



# Body compositions with Fluximax

From a typical porcelain stoneware body, a standard sodium feldspar was replaced by Fluximax perlite at 5% and 10%

| | F1 | F2 | F3 |
|---|---|---|---|
| TSMA ball clay | 5,0 | 5,0 | 5,0 |
| German clay 1 | 24,0 | 24,0 | 24,0 |
| German clay 2 | 16,0 | 16,0 | 16,0 |
| Std Turkish feldspar | 30,0 | 25,0 | 20,0 |
| RF4 feldspar | 25,0 | 25,0 | 25,0 |
| Fluximax | | 5,0 | 10,0 |
| Total | 100,0 | 100,0 | 100,0 |
| Water | 50,00 | 50,00 | 50,00 |
| Deflocculant | 0,40% | 0,40% | 0,40% |
| Rapido milling time (min) | 20 | 20 | 20 |

There is no change in terms of slip viscosity

| | | | |
|---|---|---|---|
| Slip density | 1,705 | 1,700 | 1,700 |
| Ford cup (s) | 17 | 17 | 18 |
| Temperature (°C) | 24,3 | 24,5 | 24,5 |



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# Body compositions with Fluximax

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| RF4 feldspar | 25,0 | 25,0 | 25,0 |
| Fluximax | | 5,0 | 10,0 |
| Total | 100,0 | 100,0 | 100,0 |
| Water | 50,00 | 50,00 | 50,00 |
| Deflocculant | 0,40% | 0,40% | 0,40% |
| Rapido milling time (min) | 20 | 20 | 20 |

**Fluximax** used up to 10% as a flux booster without affecting significantly the dry bulk density and the MOR

| | | | |
|---|---|---|---|
| Pressing Force (kg/cm²) | 450 | 450 | 450 |
| Dry bulk density | 1,98 | 1,98 | 1,95 |
| Dry Modulus of Rupture (MPa) | 1,91 | 2,00 | 1,73 |



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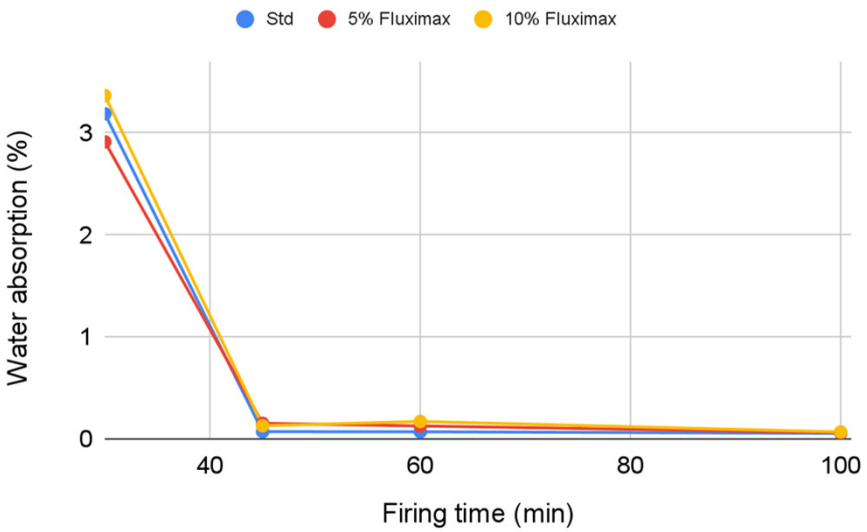
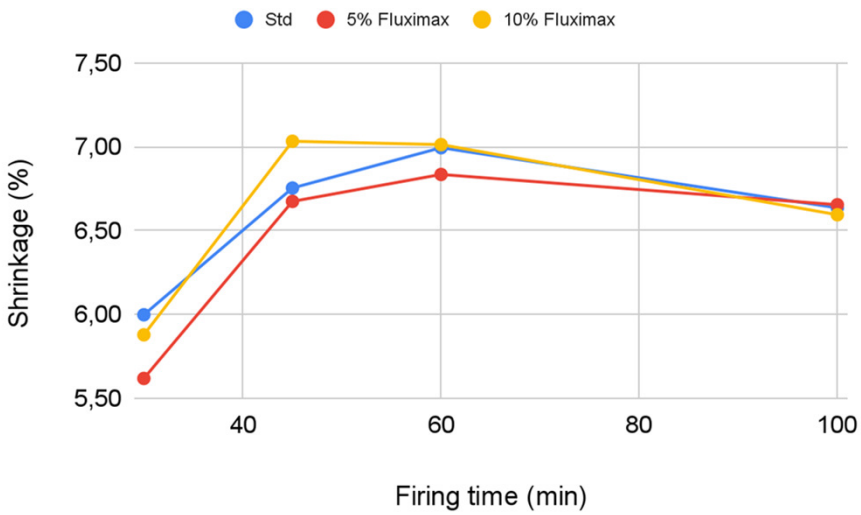
# Body compositions with perlite




Firing in a roller gas kiln at 1200°C with a variable cycle time.

Fusibility is not affected by the substitution of feldspar by Fluximax perlite. The shrinkage and firing range are similar.



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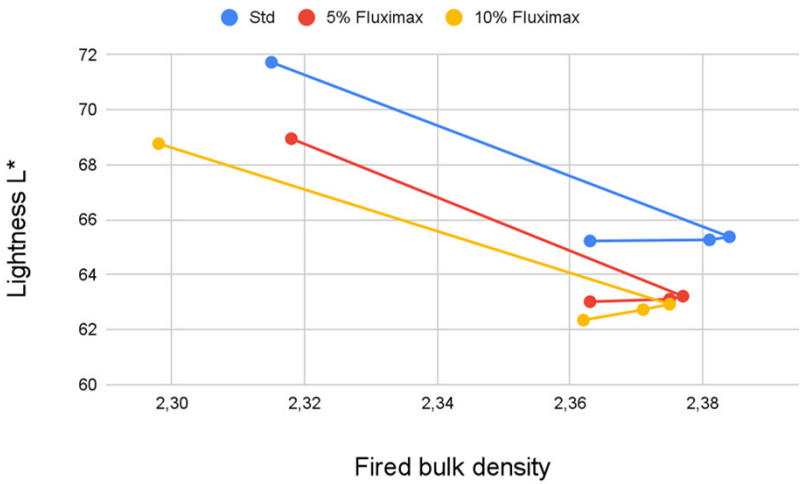
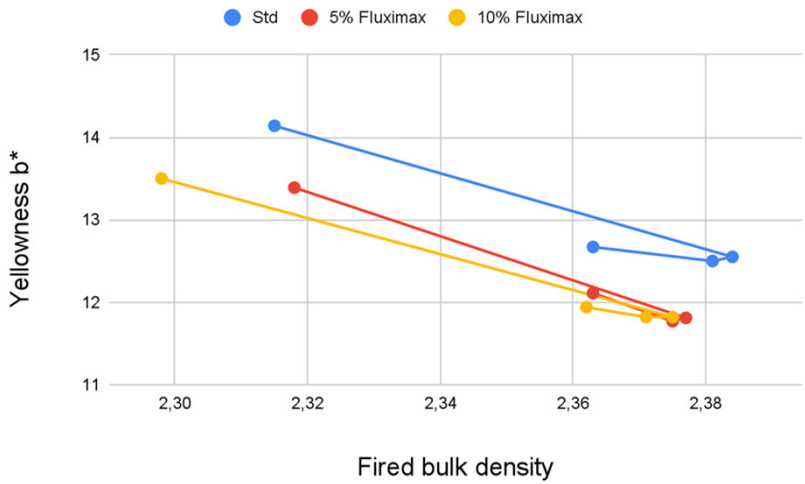
# Body compositions with perlite




Firing in a roller gas kiln at 1200°C with a variable cycle time.

L* value is affected by the higher Fe2O3 content from Fluximax perlite, but the b* value (yellowness) decreases as well.



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# Takeaways

**Fluximax** perlite can be used to substitute standard sodium feldspars in base bodies ( i.e. non white) :

- ➔ Fluidity, density , MOR, and fusibility remain stable.
- ➔ Up to 10% feldspar can be replaced with **Fluximax**.
- ➔ L* and b* values can decrease according to feldspar and % substituted.



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# Solutions for energy savings

## Introduction

## Fluximax

## Ceraflash



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# Ceraflash

**Ceraflash** is a new product range. The products consist in blends of natural minerals, designed to decrease energy consumption in ceramic firing.

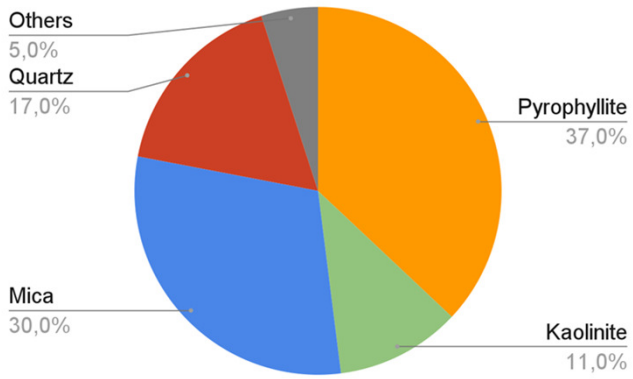
TYPICAL PROPERTIES

| CHEMICAL ANALYSIS (%) | Value |
|---|---|
| $SiO_2$ | < 56 |
| $Al_2O_3$ | > 28 |
| $Fe_2O_3$ | < 0.6 |
| $TiO_2$ | < 1.3 |
| $K_2O$ | > 5 |
| $Na_2O$ | 0.2 |
| CaO | 0.1 |
| MgO | 0.2 |
| L.O.I. | 4.5 |
| F | 0.5 |

Whiteness

Fusibility

Energy saving



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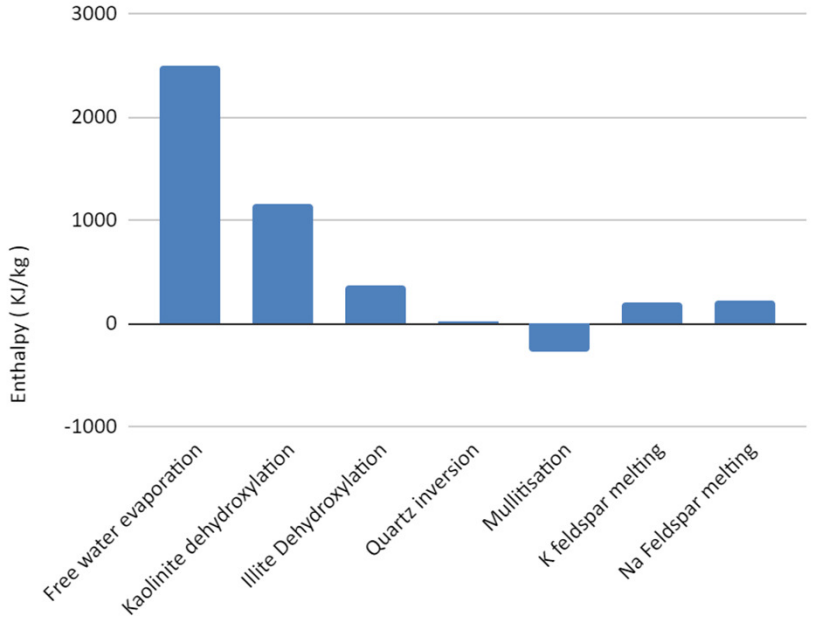
# Why Ceraflash

The various reactions taking place during firing consume or sometimes produce energy.

Kaolinite dehydroxylation is a high energy-intensive reaction among the ones taking place in porcelain stoneware firing.

Replacing kaolinite at least partially by another mineral like pyrophyllite having a lower loss on ignition, helps to reduce the energy needed during firing.




*Source : Estimation of the heat of reaction in traditional ceramic compositions*
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# Body compositions with Ceraflash

3 Body compositions prepared to check the impact of Ceraflash on the body properties.

- ➔ Stable $Al_2O_3$ content
- ➔ $K_2O$ increased
- ➔ LOI (Loss on Ignition) decreased

The ford cup value increases with kaolin and Ceraflash

| | F13 | F15 | F17 |
|---|---|---|---|
| Westerwald clay | 25,0 | 33,0 | 28,0 |
| TSMA clay | 5,0 | 5,0 | 5,0 |
| Kaolinitic Indian clay | 15,0 | | |
| Kaolin | | 7,0 | |
| Ceraflash | | | 12,0 |
| Na Feldspar | 30,0 | 30,0 | 30,0 |
| RF4 | 25,0 | 25,0 | 25,0 |
| **Total** | **100,0** | **100,0** | **100,0** |
| Al2O3 | 20,29 | 20,71 | 20,60 |
| K2O | 1,49 | 1,63 | 2,18 |
| LOI | 4,10 | 4,07 | 3,35 |
| LOI difference | | -0,8% | -18,2% |

| | | | |
|---|---|---|---|
| Water | 50,0 | 50,0 | 50,0 |
| Deflocculant | 0,4 | 0,4 | 0,4 |

| | | | |
|---|---|---|---|
| Slip density | 1,705 | 1,706 | 1,711 |
| Ford cup (s) | 20 | 26 | 30 |
| Temperature (°C) | 21,7 | 21,2 | 21,3 |
| Sieving @63 µm (%) | 0,9 | 1,2 | 0,9 |



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**Diapositiva 13**

**1** @cedric.poilly@imerys.com this is a drawback. Let's be prepared to answer to question on this respect. How can we fix it? Let's be prepared to show that fixing cost is lower then benefits achieved.
Danilo Frulli; 13/02/2023

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| Na Feldspar | 30,0 | 30,0 | 30,0 |
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| LOI | 4,10 | 4,07 | 3,35 |
| LOI difference | | -0,8% | -18,2% |

| | | | |
|---|---|---|---|
| Pressing force (Kg/cm²) | 450 | 450 | 450 |
| Dry bulk density | 1,95 | 1,93 | 1,93 |
| Dry Modulus Of Rupture (MPa) | 2,05 | 1,84 | 1,88 |

Dry bulk density and dry MOR are in the same range than for a kaolin.



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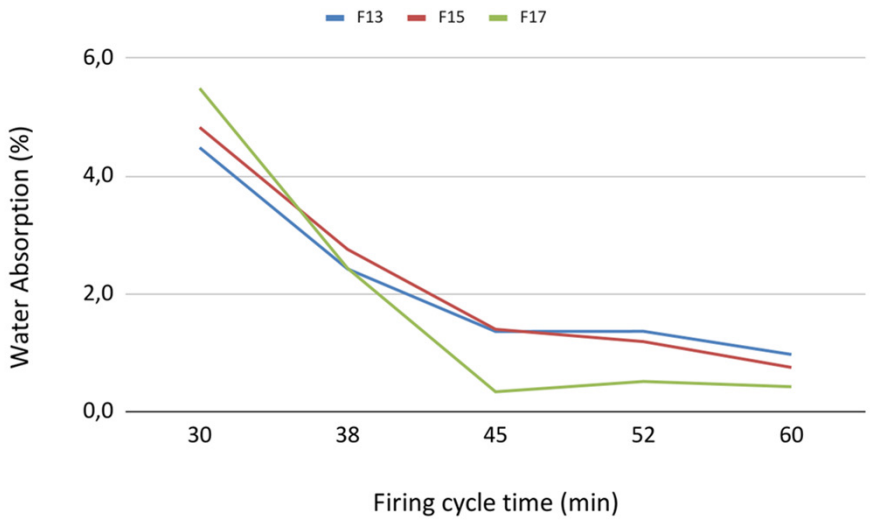
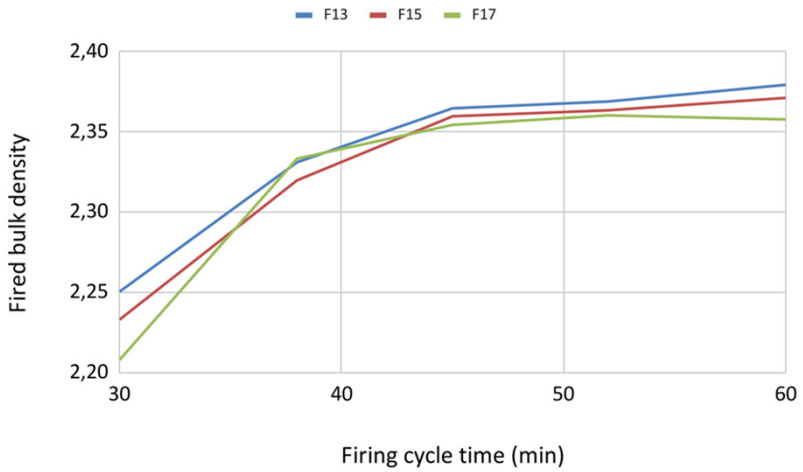
# Body compositions with Ceraflash




Firing in gas roller kiln at 1200°C with a variable firing cycle.

➔ A lower water absorption can be reached with Ceraflash, quicker than with kaolinitic clay or kaolin



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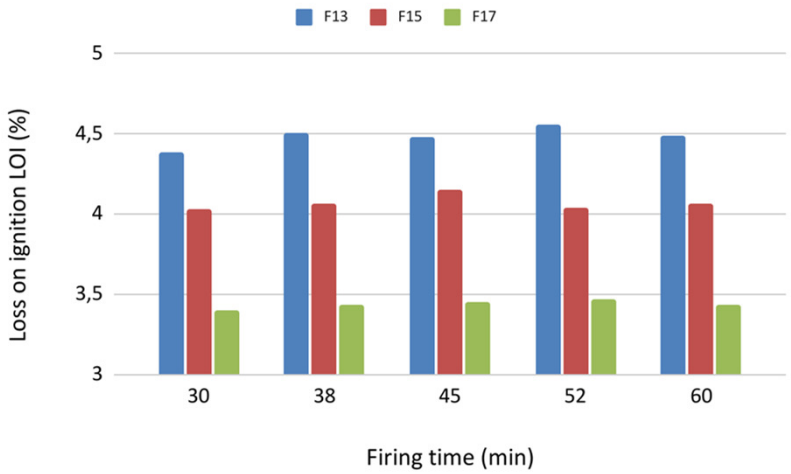
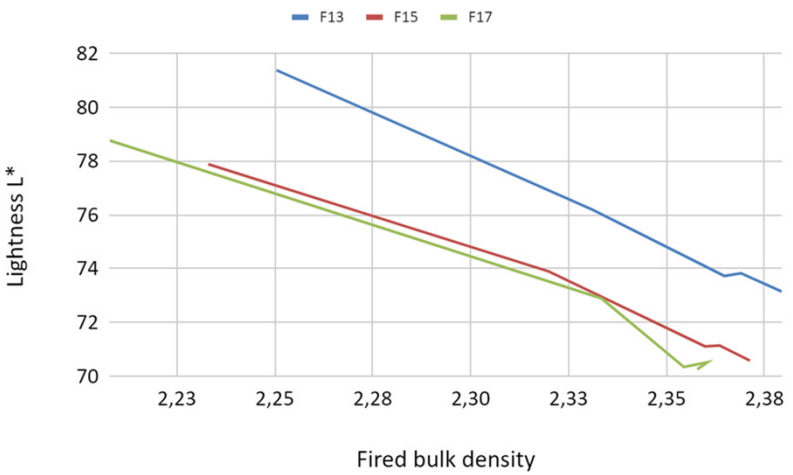
# Body compositions with Ceraflash




Firing in gas roller kiln at 1200°C with a variable firing cycle.

- ➔ On average a reduction of up to 1 pt of LOI is measured ( i.e. more than 20% reduction )
- ➔ L* value at peak density is lower due to a difference in water absorption



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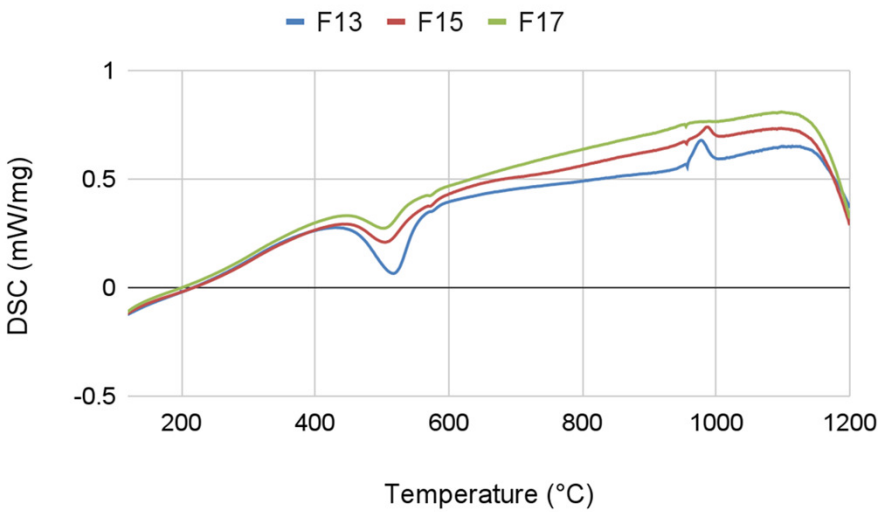
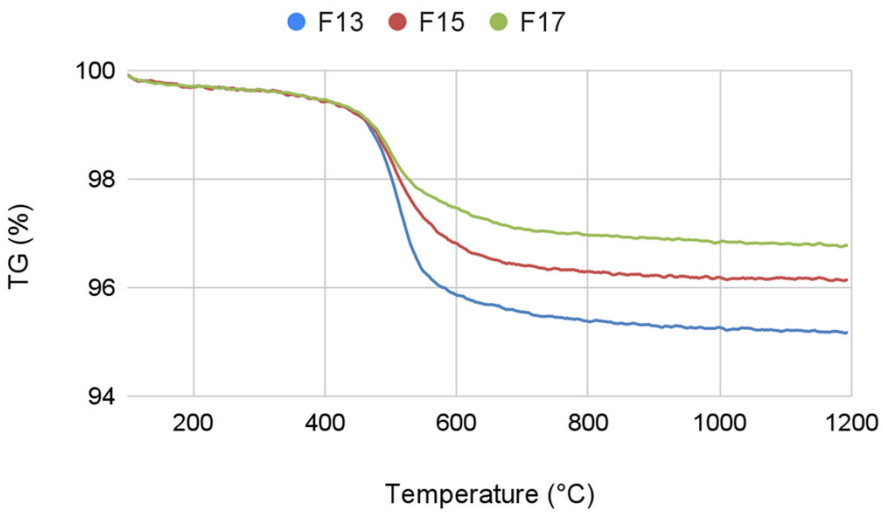
# Firing energy balance




1 DSC curves show a huge decrease of the energy required for dehydroxylation ( 450-550 °C) of about 65%.

There is also a reduction of the peak of mullite (950-1000 °C )

The TG curves show a total reduction of LOI of 1.5 pts from 4.8 to 3.3 %



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## Diapositiva 17

**1** by how much? 10-15%?
Camille AURIAULT; 15/02/2023

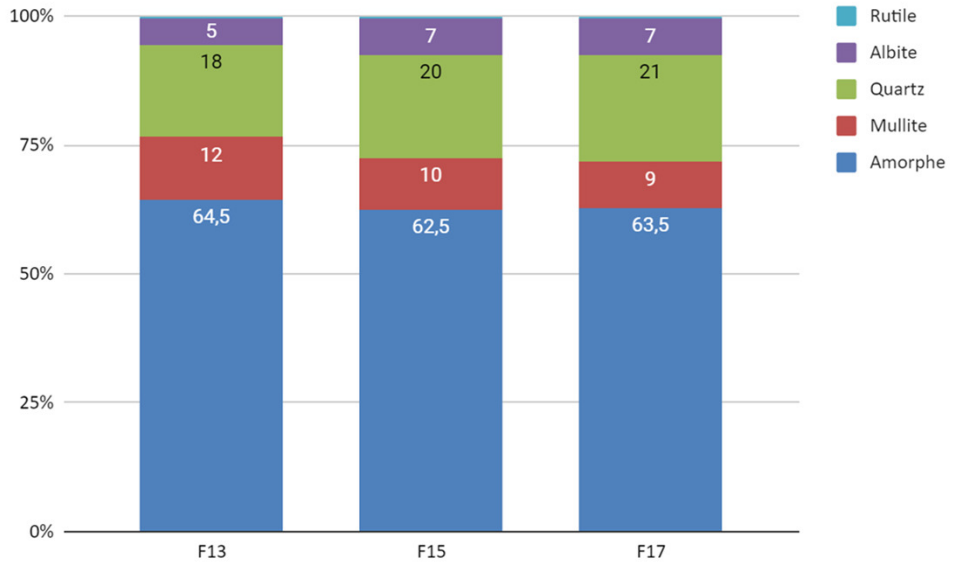
**1** Much more than that , about 2/3, I amend accordingly
Cedric Poilly; 15/02/2023

# Phase analysis

2 The mineralogical phases observed after firing at 1200°C by quantitative X-Ray diffraction are the usual ones :

- Amorphous phase
- Quartz
- Mullite
- Albite
- Rutile

There is a slight decrease of the mullite content in F15 and F17 versus F13 mostly offset by quartz



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**Diapositiva 18**

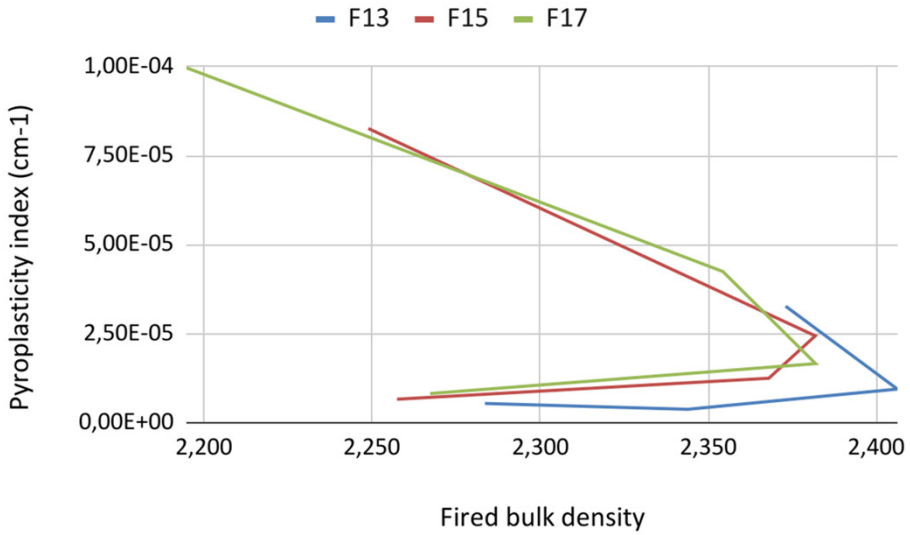
**2** @luc.bourgy@imerys.com
Je préfère garder cette slide pour expliquer la diminution du pic de mullite dans le slide précédent. Je pense que c'est plus rassurant que de laisser un doute, même si la valeur diminue un peu.
Cedric Poilly; 15/02/2023

# Pyroplasticity

In order to check the pyroplasticity, deformation was measured at various firing temperatures from 1120 to 1200 °C peak temperature.

$$PI = \frac{sb^2}{l^4}$$

s : max deformation
b : bar thickness
l : distance between supports



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# Takeaways

**Ceraflash** range has a great potential to :

- Reduce the firing time by introducing a more favourable $Al_2O_3$ / $K_2O$ balance
- Reduce the energy consumption by reducing the energy needed for dehydroxylation of clays

## Thank you for your attention

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