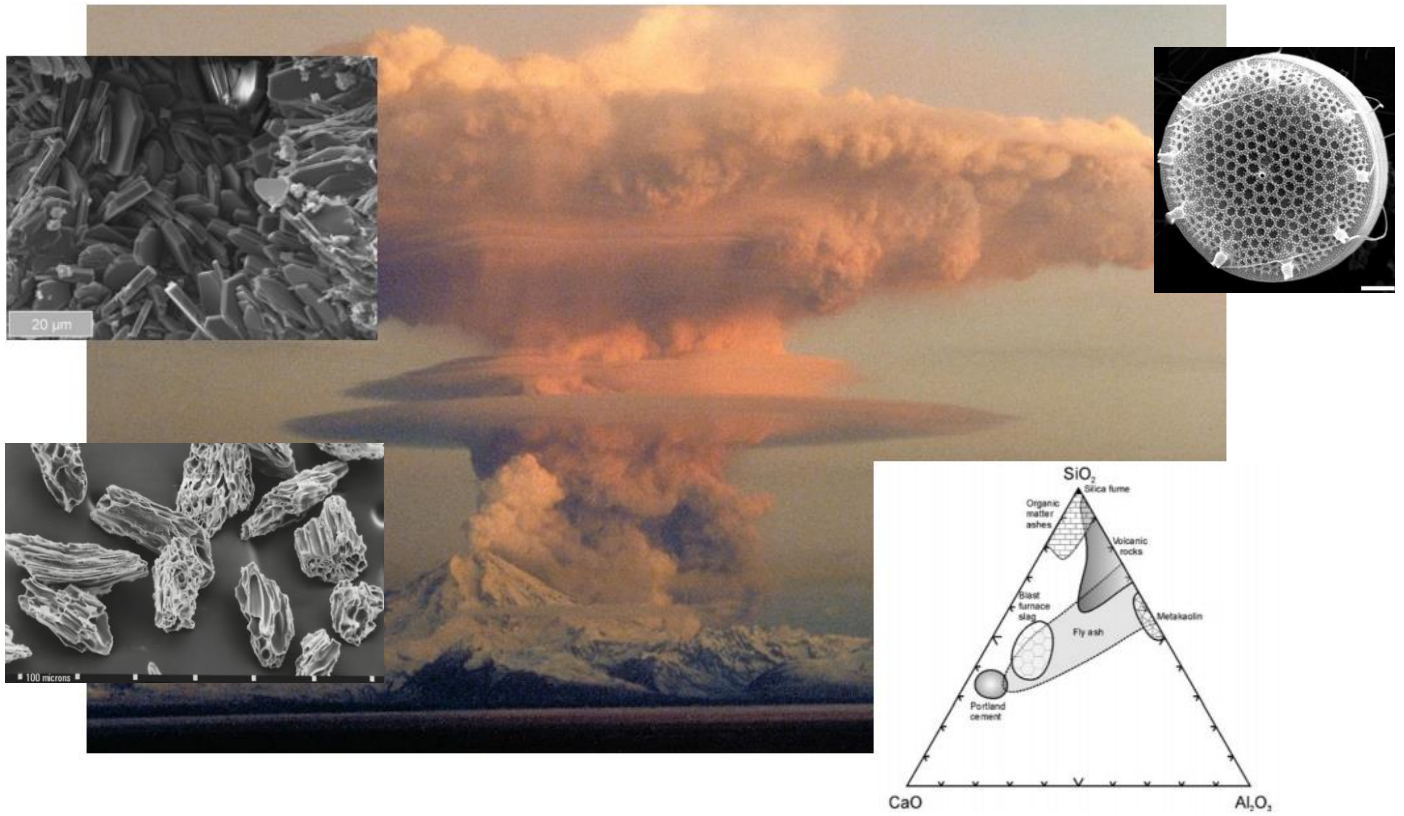


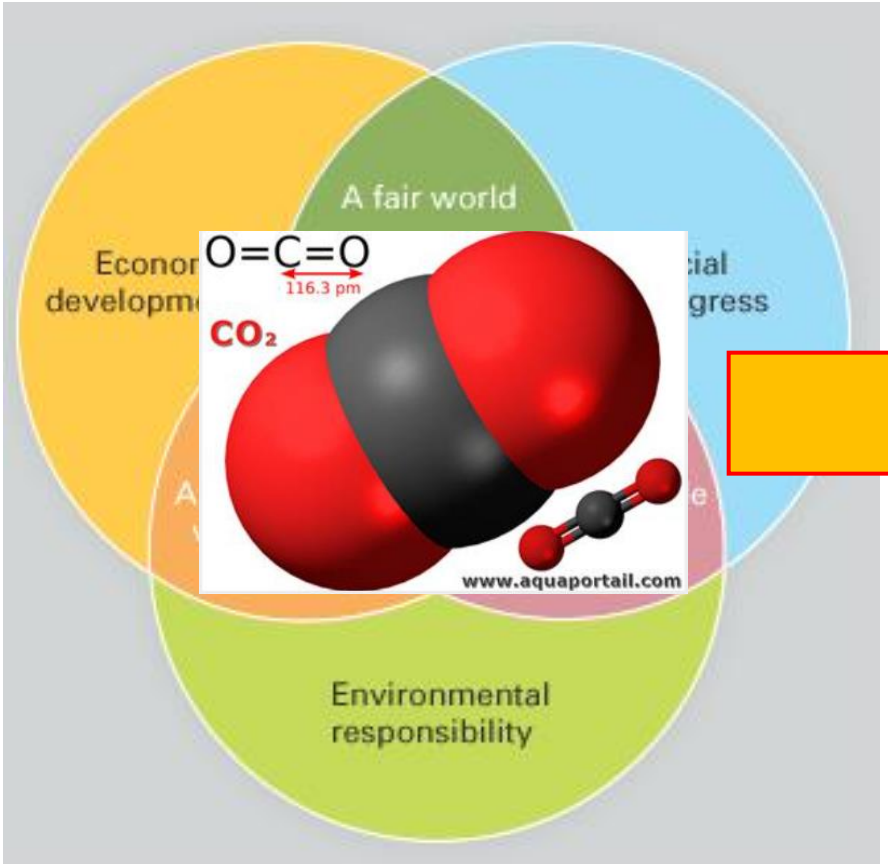
DETOCS PROJECT

Past-current and emerging SCMs: how to use them?

Wednesday December 5th, 2024

Laurent Izoret

Bruntland' report (1987)



→ As a consequence, we have to lower as far as possible the cement CO_2 footprint

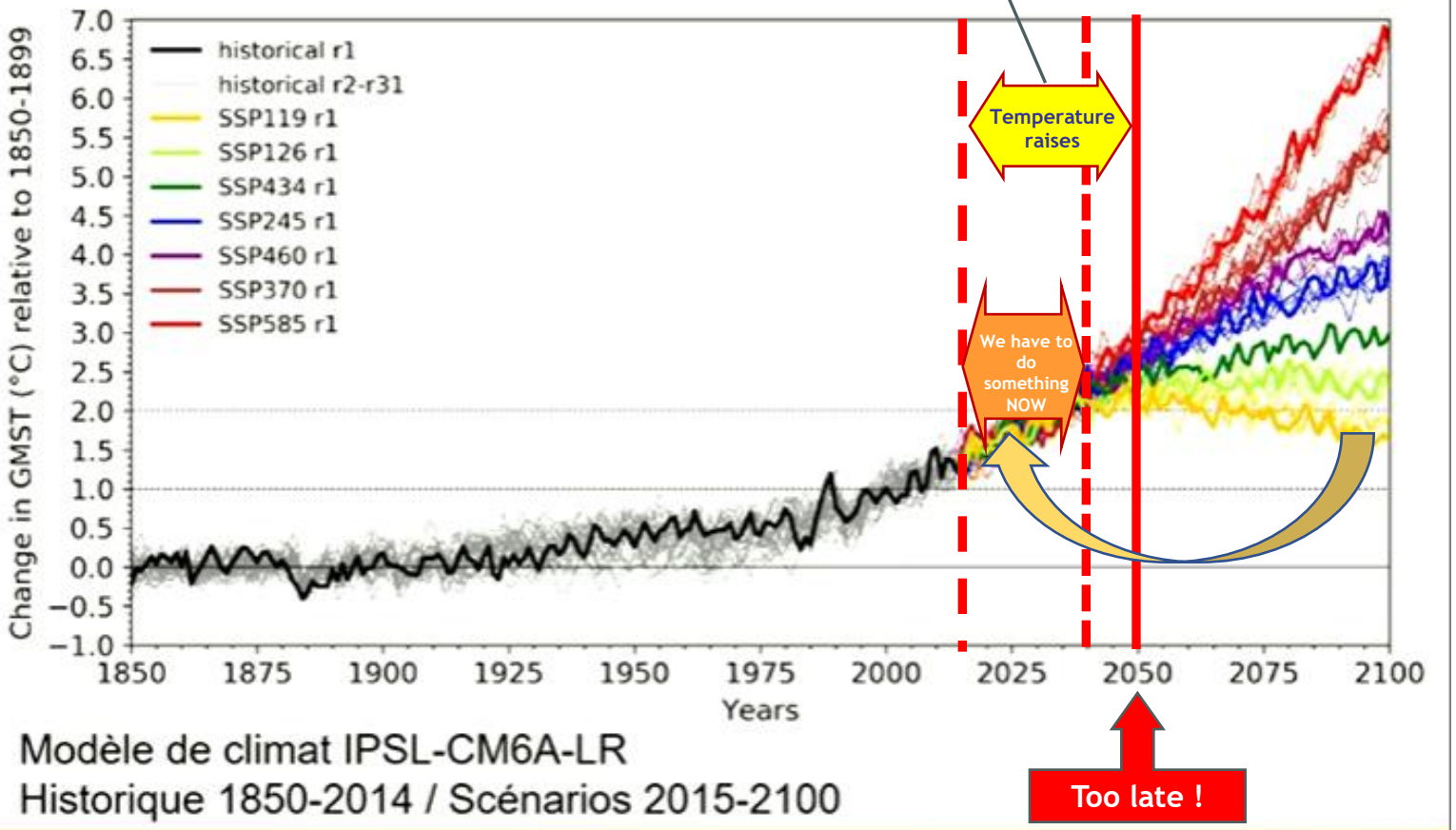
Introduction

→ Therefore, we must better manage our available resources but also
→ Lower as far as possible the cement CO_2 footprint
→ In other words, there is a global urgency to reduce CO2 footprint, that concern us

Introduction

JM Jancovici

CO_2 persistence in the atmosphere

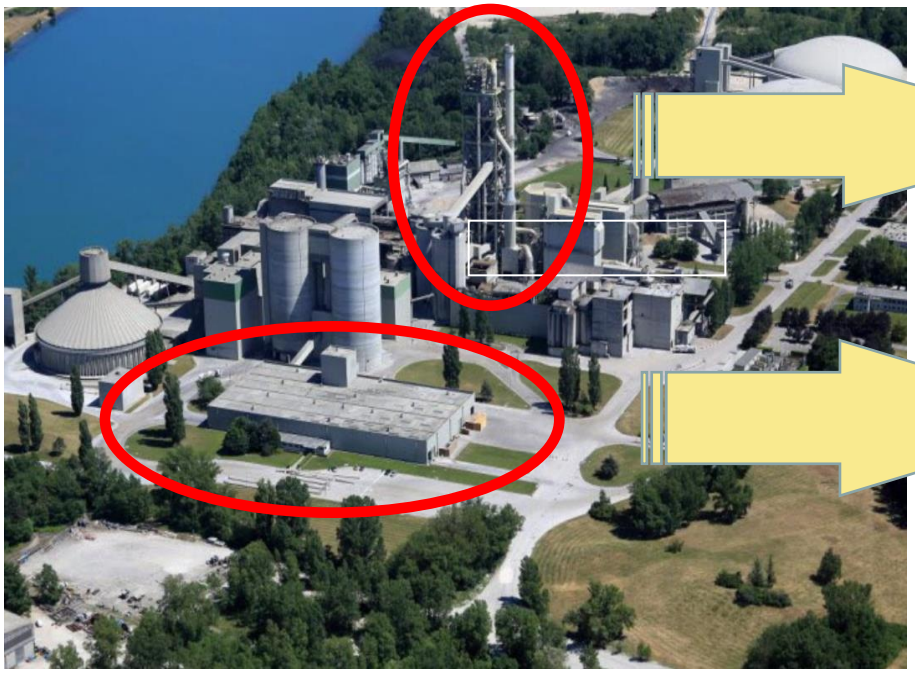


carbone4

www.jancovici.com

THE SHIFT PROJECT

CO_2 mitigation in cement industry: Two unbalanced ways…



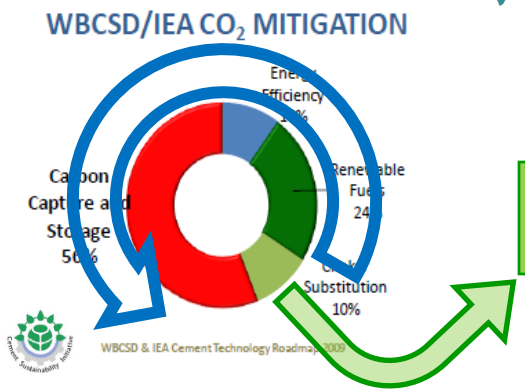
→ The Process route

- ✓Use of alternative Fuels & materials,
- ✓Energy efficiency
- ✓CCS & CCU/R

→ The Product route

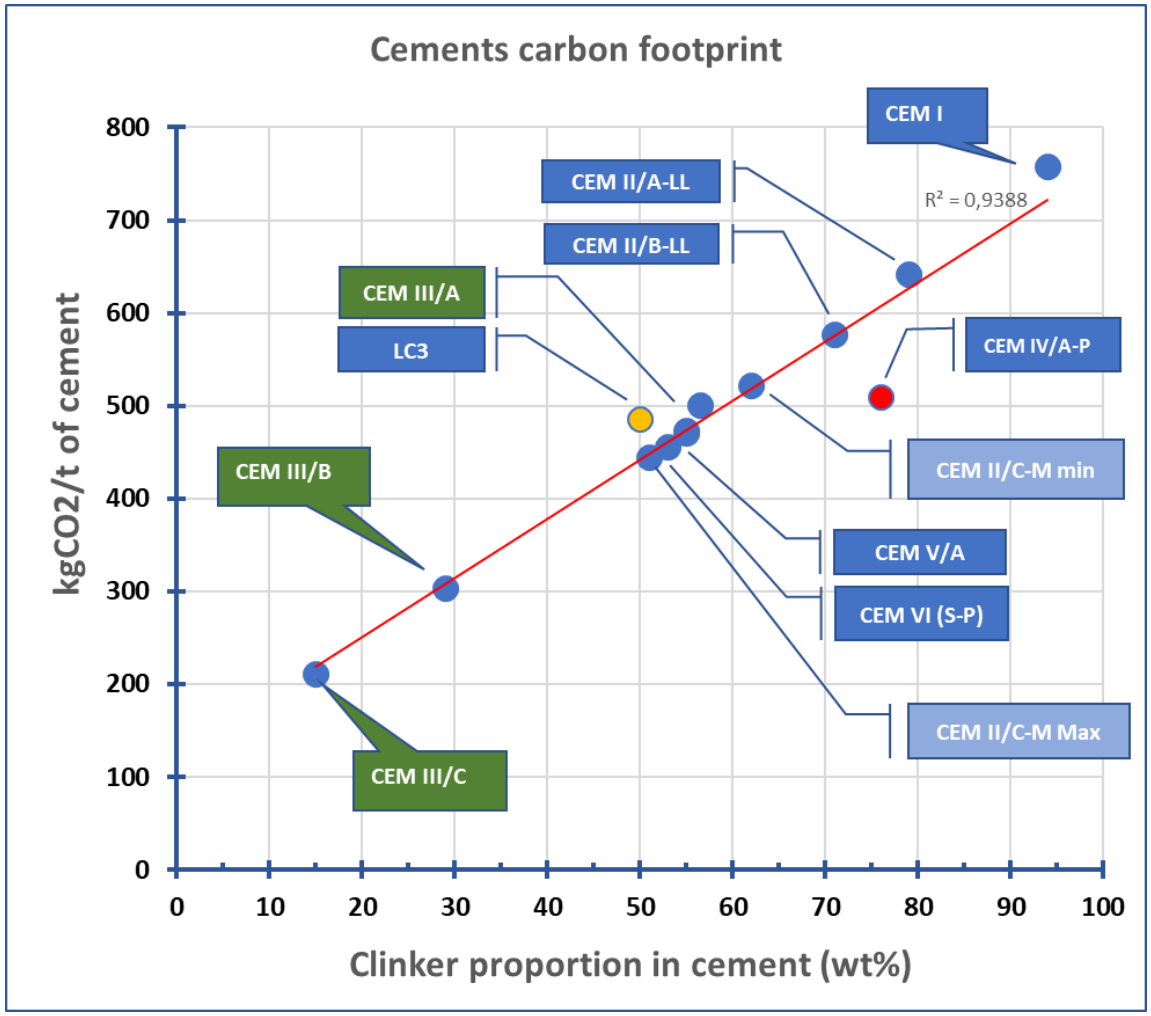
- ✓ Cement K content
- ✓ New constituents (low CO_2)
- ✓ Circular economy
- ✓ Synergy between constituents
- ✓ Normative evolution

90% may be in 10 years



10% « immediately »

Relationship : cement composition vs CO_2 footprint

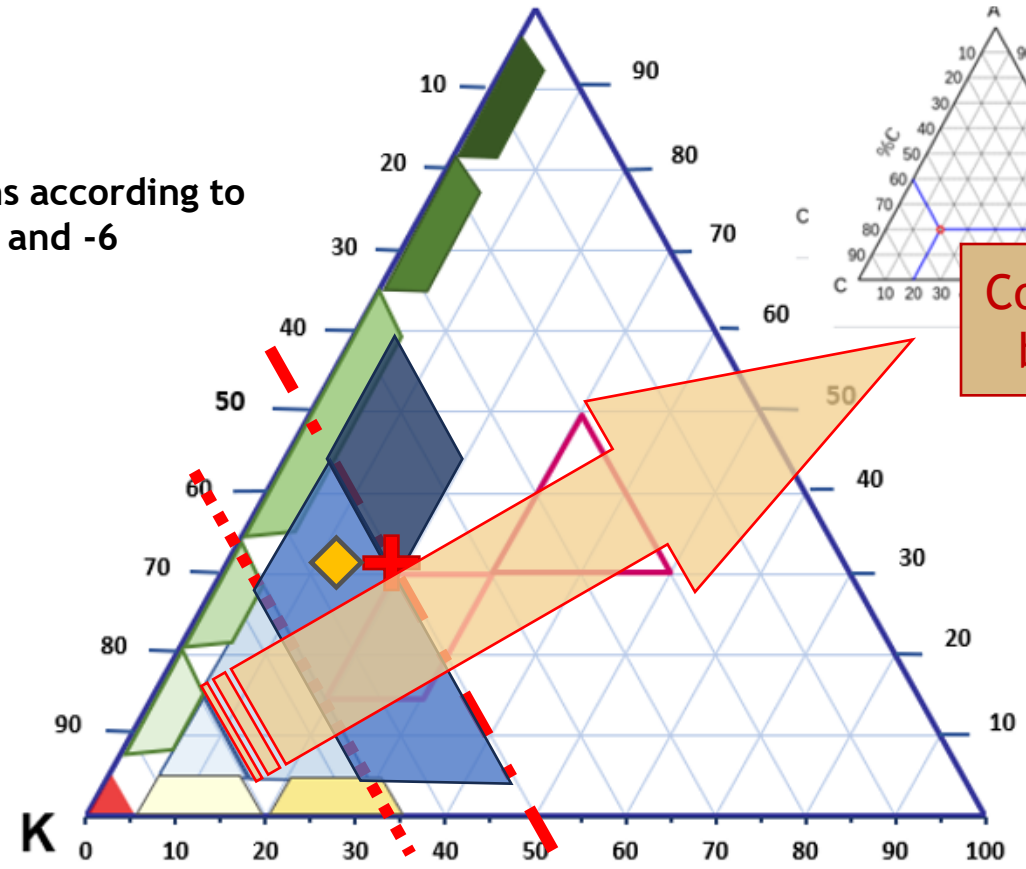


Introduction

Consequence on cement composition

S, P, Q, D

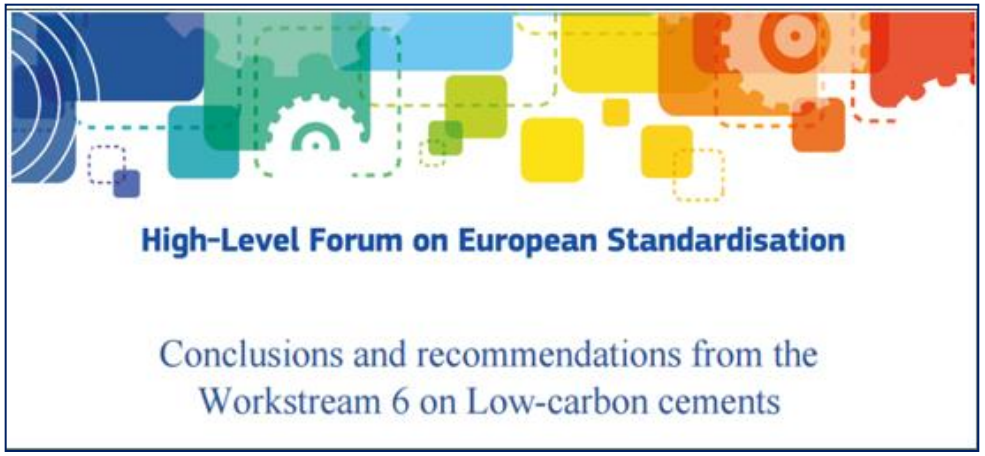
Compositions according to EN197-1, -5 and -6



Cooperative Interactions between constituents

L, V, P, F

Current trends in devlopment



Forthcoming usable SCMs to be:

- Available,
- Predictable
- Acceptable
- Durable and sustainable

- Still room for Clinker production efficiency
- Still room for cement production efficiency
- **Still room for increasing SCMs content e.g. Limestone.**

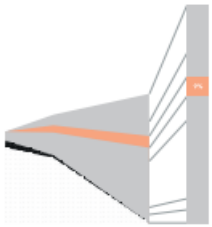
→The fastest and the cheapest way to reduce CO_2

Past and current SCM'S

FAMILY	TYPE	SUB-TYPE	MECHANISM	MATERIAL EXAMPLE
SCMs	Non-Active	Natural	Uncalcined	Filler effect	Ground Limestone
			Calcined	Filler effect	Ground Calcined quartz pebbles
		Artificial	Uncalcined	Filler effect	Recycled Concrete Fines (RCF)
			Calcined	Filler effect	
	Active	Natural			
		Artificial			

GCCA Concrete Future
Cement Industry Net Zero Progress Report 2024/25

Cement and Binders

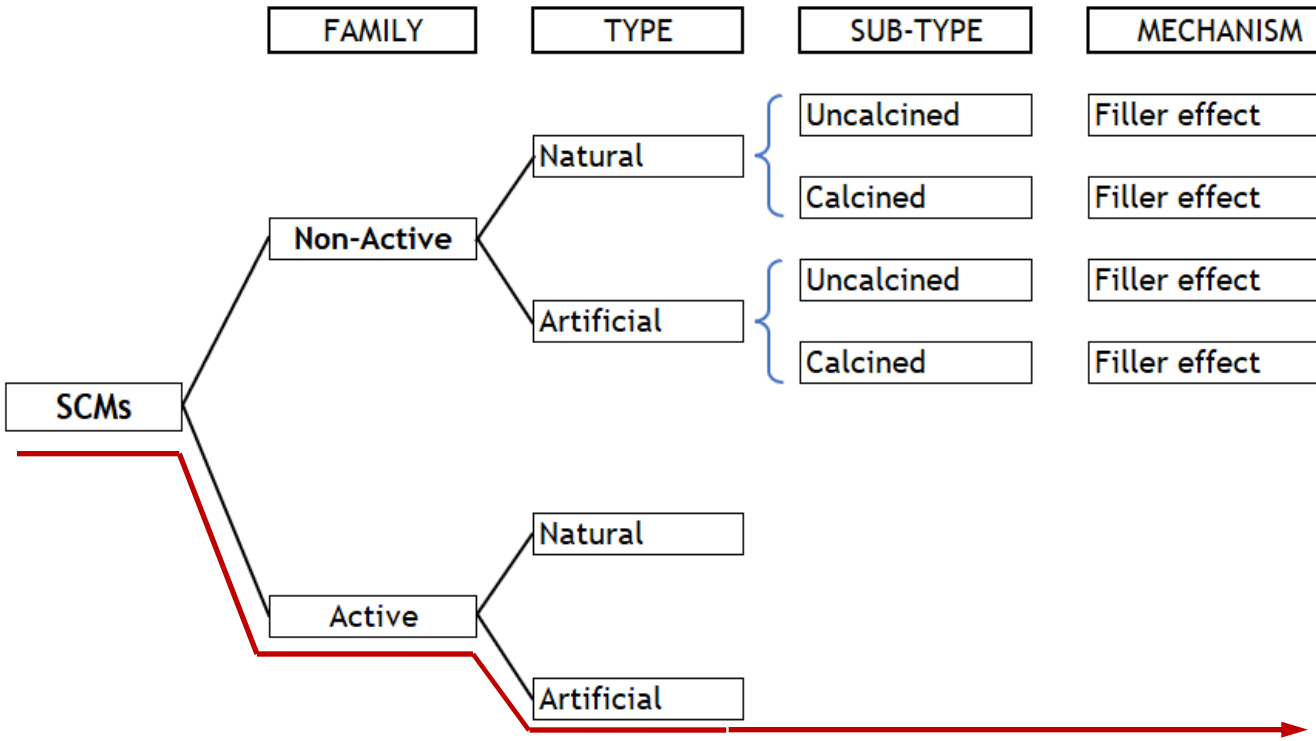


9% contribution to Net Zero and 350Mt CO_2 emission savings in 2050

"In coming decades there will be increased use of ground limestone and calcined clays to further reduce the Portland clinker to binder ratio.

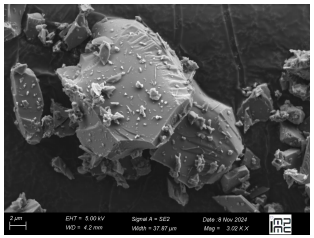
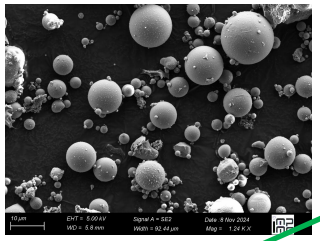
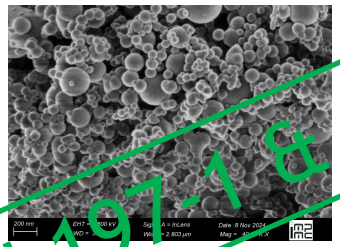
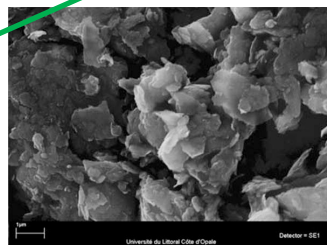
- Still room for increasing SCMs content e.g. Limestone.

Past and current SCM'S



Past and current SCM'S

Active & **ARTIFICIAL SCMs**

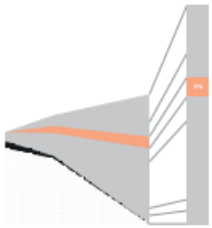
Blast Furnace slag	Fly ash (V, W)	Silica Fume	Burned organic matter residue	Burned clay/shale
				
Izoret & Estève 2024	Izoret & Estève 2024	Izoret & Estève 2024		Lemya Djeffal et al. 2014 Desalination and Water Treatment
• From Blast furnace • Granulation process	• From Coal combustion • Si-Al or Si-Ca	• From Fe-Si industry • Pure vitreous silica		• Calcined clay • Burnt shale

Already « EN 197-1 & -5» accepted

Materials with well specified production conditions : two-way relationship "material ←→ production conditions"

GCCA Concrete Future
Cement Industry Net Zero Progress Report 2024/25

Cement and Binders



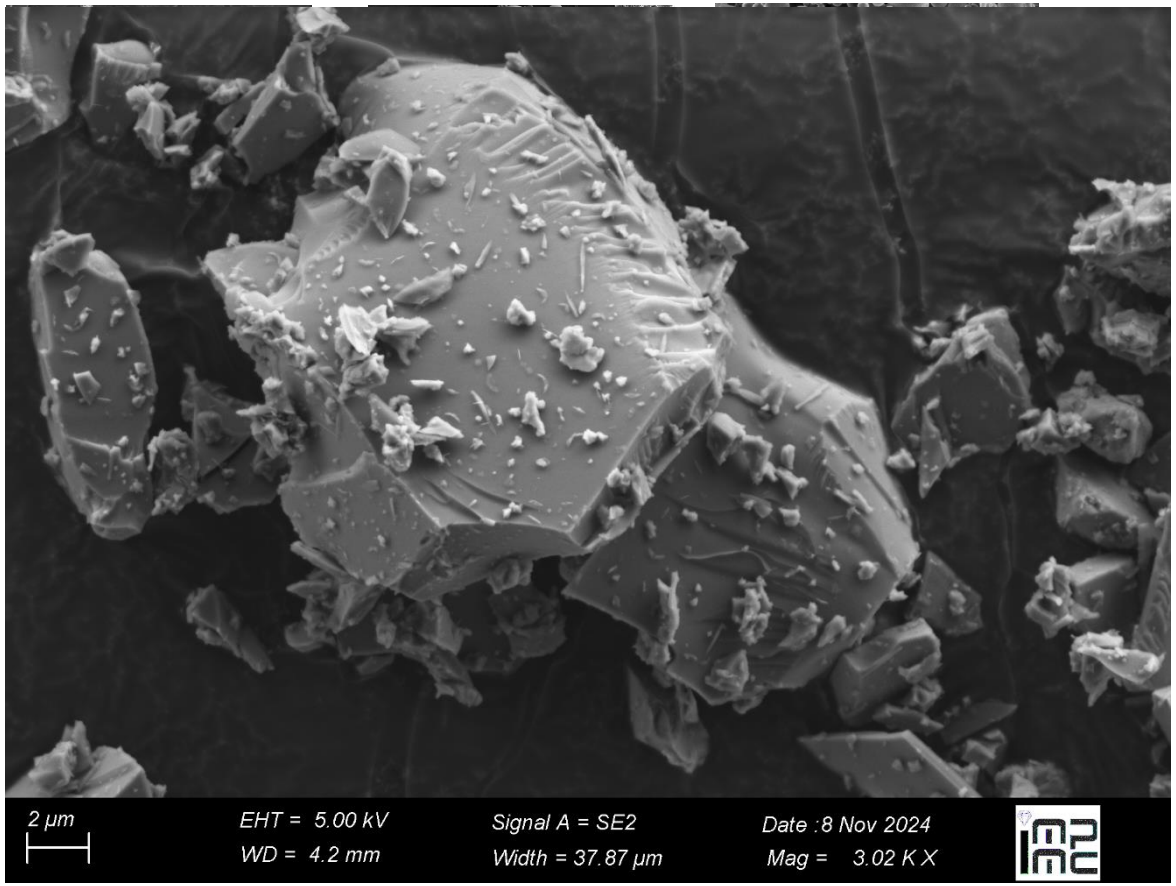
9% contribution to Net Zero and 350Mt CO_2 emission savings in 2050

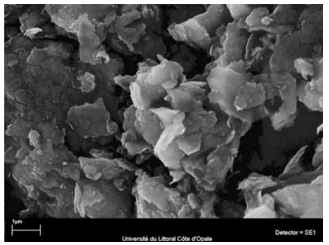
At the cement plant or the concrete plant, fly ash, ggbs, ground limestone and other materials, known as supplementary cementitious materials (SCMs) can be added to Portland clinker cement to deliver concretes with reduced CO_2 emissions whilst maintaining required performance. In some applications the concrete performance is enhanced.

Past and current SCM'S

Active & **ARTIFICIAL SCMs**

- Blast Furnace slag
- Fly ash (V, W)
- Silica Fume
- Burned organic matter residue
- Burned clay/shale





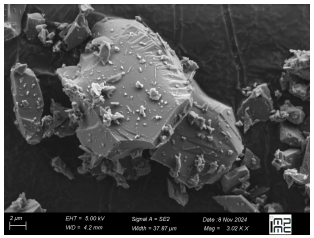
Lemya Djeffal et al. 2014
Desalination and Water Treatment

- **Calcined clay**
- **Burnt shale**

Past and current SCM'S

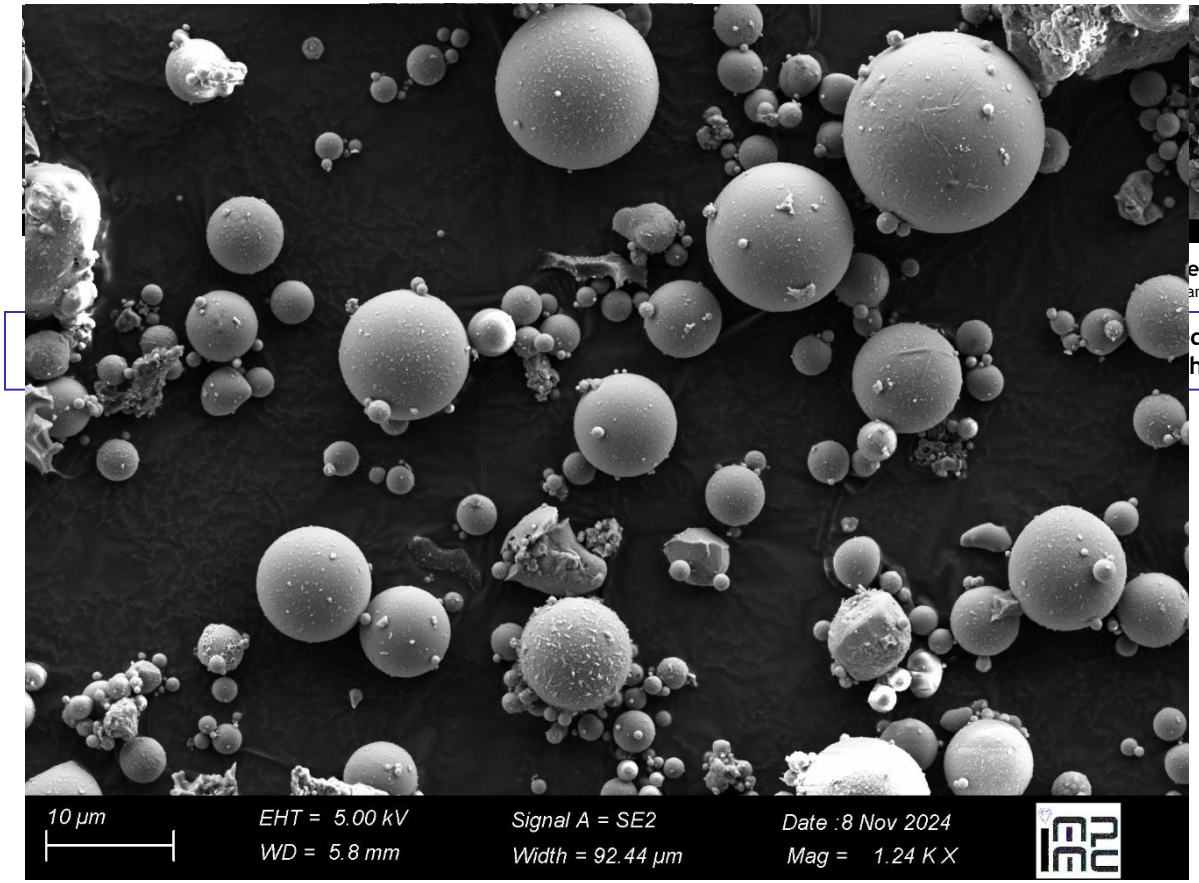
Active & **ARTIFICIAL SCMs**

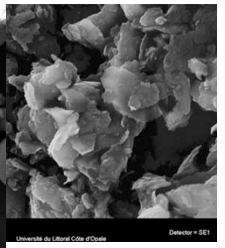
- **Blast Furnace slag**
- **Fly ash (V, W)**
- **Silica Fume**
- **Burned organic matter residue**
- **Burned clay/shale**



Izoret & Estève 2024

- From Blast furnace
- Granulation process





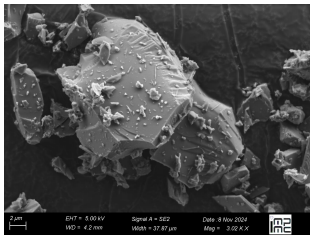
effal et al. 2014
and Water Treatment

d clay
hale

Past and current SCM'S

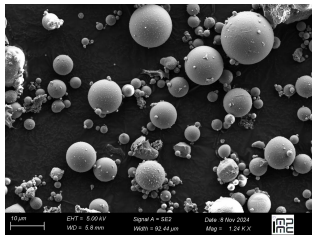
Active & **ARTIFICIAL SCMs**

- **Blast Furnace slag**
- **Fly ash (V, W)**
- **Silica Fume**
- **Burned organic matter residue**
- **Burned clay/shale**



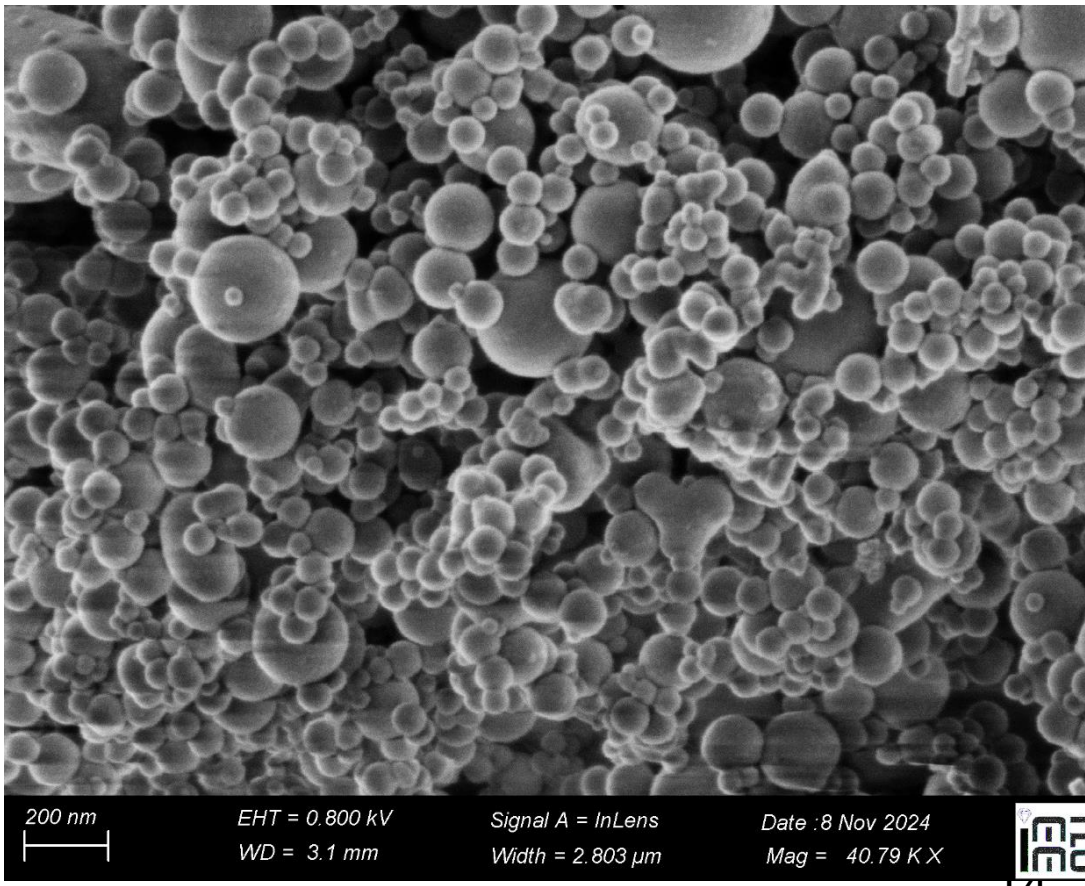
Izoret & Estève 2024

- From Blast furnace
- Granulation process



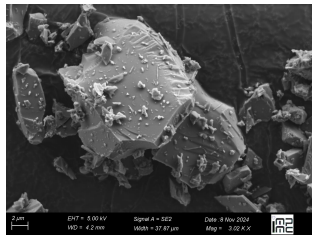
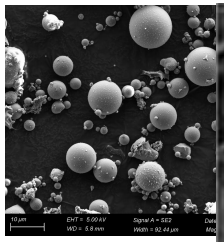
Izoret & Estève 2024

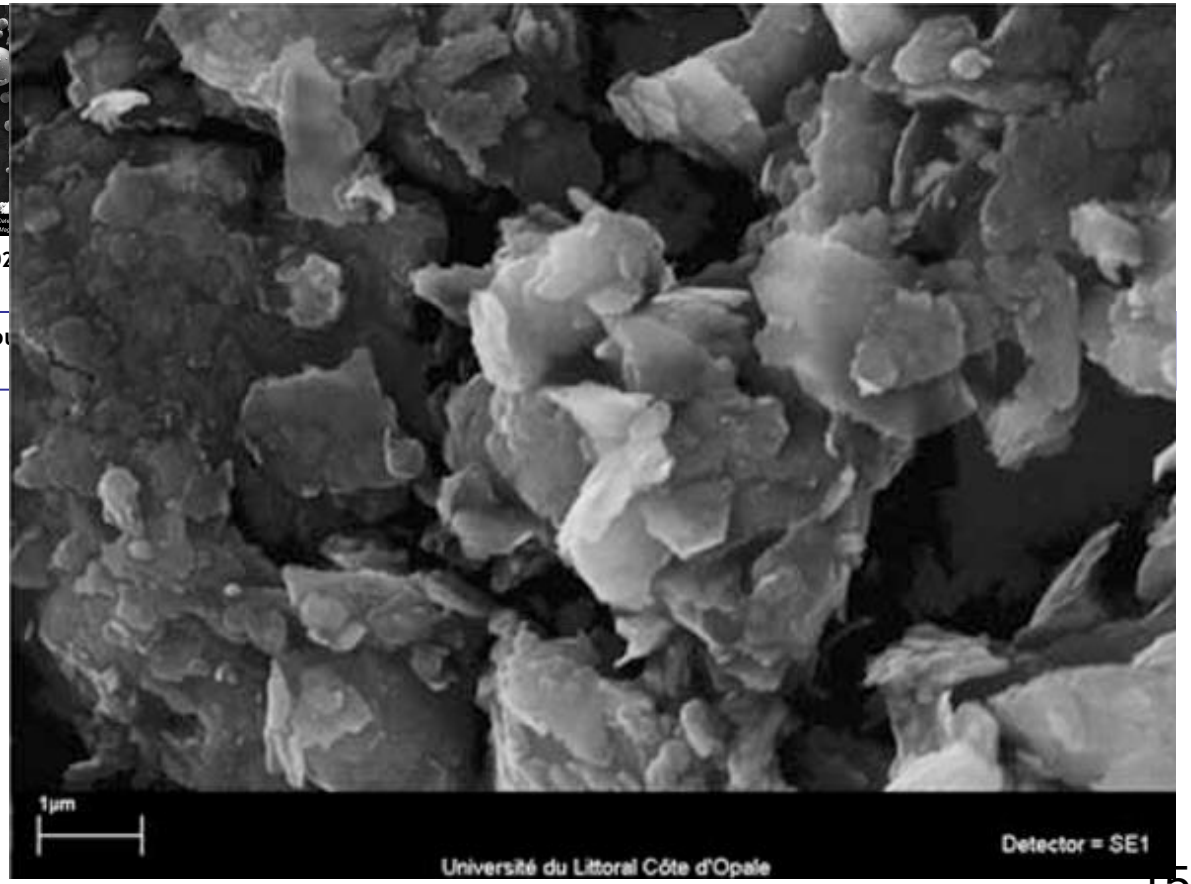
- From Coal combustion
- Si-Al or Si-Ca



Past and current SCM'S

Active & **ARTIFICIAL SCMs**

- **Blast Furnace slag**
  - 
  - Izoret & Estève 2024
  - From Blast furnace
  - Granulation process
- **Fly ash (V, W)**
  - 
  - Izoret & Estève 202
  - From Coal combu
  - Si-Al or Si-Ca
- **Silica Fume**
- **Burned organic matter residue**
- **Burned clay/shale**



Past and current SCM'S

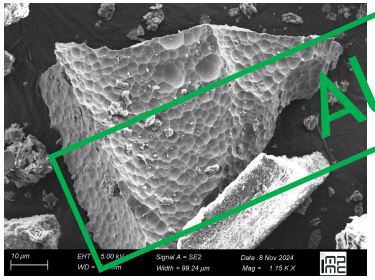
Active & ARTIFICIAL SCMs

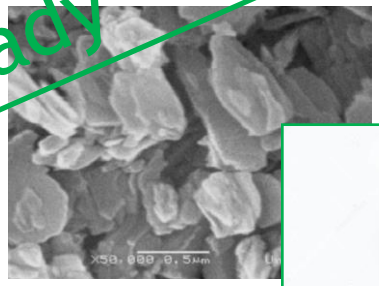
- Blast Furnace slag
- Fly ash (V, W)
- Silica Fume
- Burned organic matter residue
- Burned clay/shale

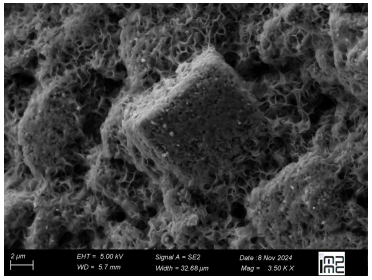
Active & NATURAL SCMs

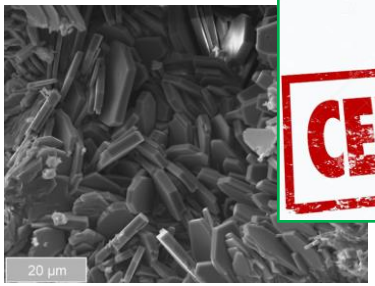
- VOLCANIC ORIGIN
  - Unaltered pyroclastic materials
    - Vitreous pumices & ashes
  - Altered pyroclastic materials
    - Zeolitised tuffs
- SEDIMENTARY ORIGIN
  - Chemical sediments
    - Hydrothermal siliceous sinters
  - detrimental sediment
    - Diatomeous earth
    - Gaize
    - Radiolarite

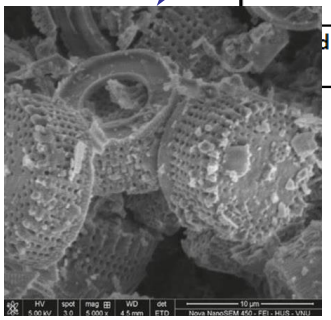
Already « EN 197-1 & -5 » accepted

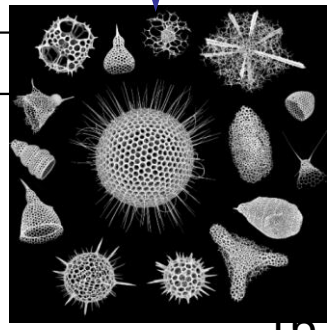






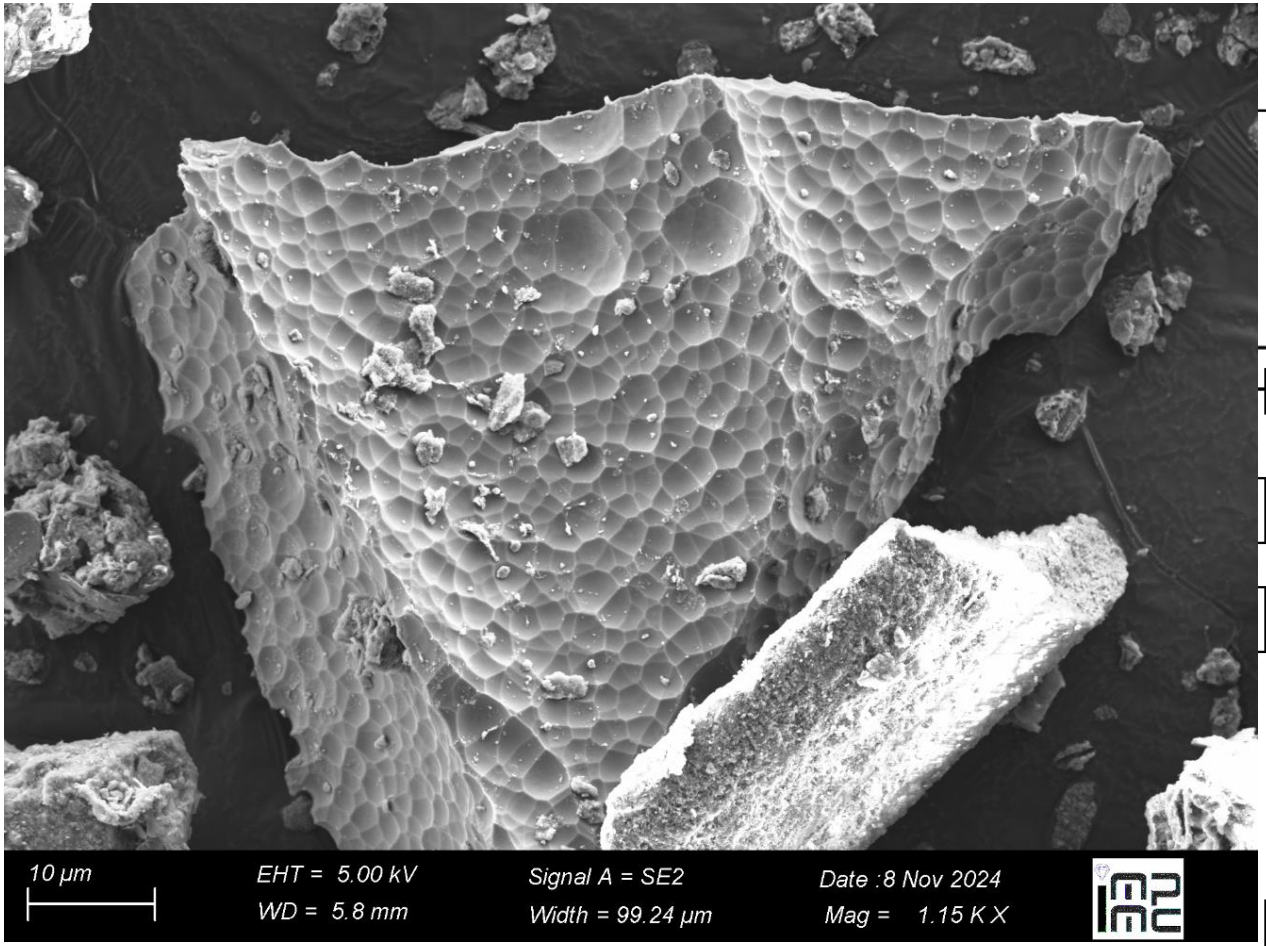




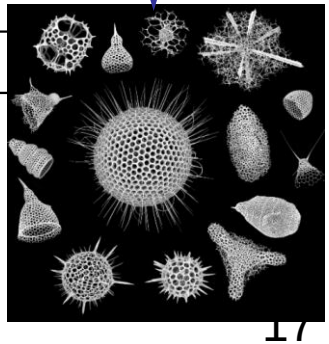


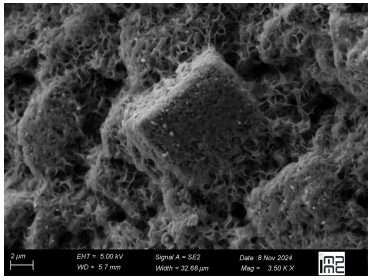
Snellings et al. 2012
RevMinGeochem

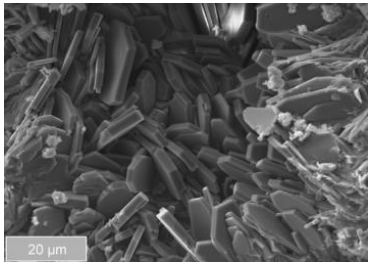
Past and current SCM'S



- Burned clay/shale
- SEDIMENTARY ORIGIN
  - detrimental sediment
  - Diatomeous earth
  - Gaize
  - Radiolarite
- Materials of mixed origin







Snellings et al. 2012
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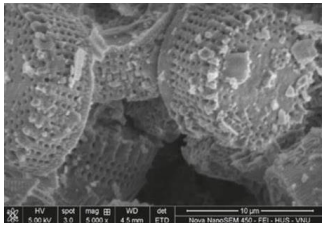
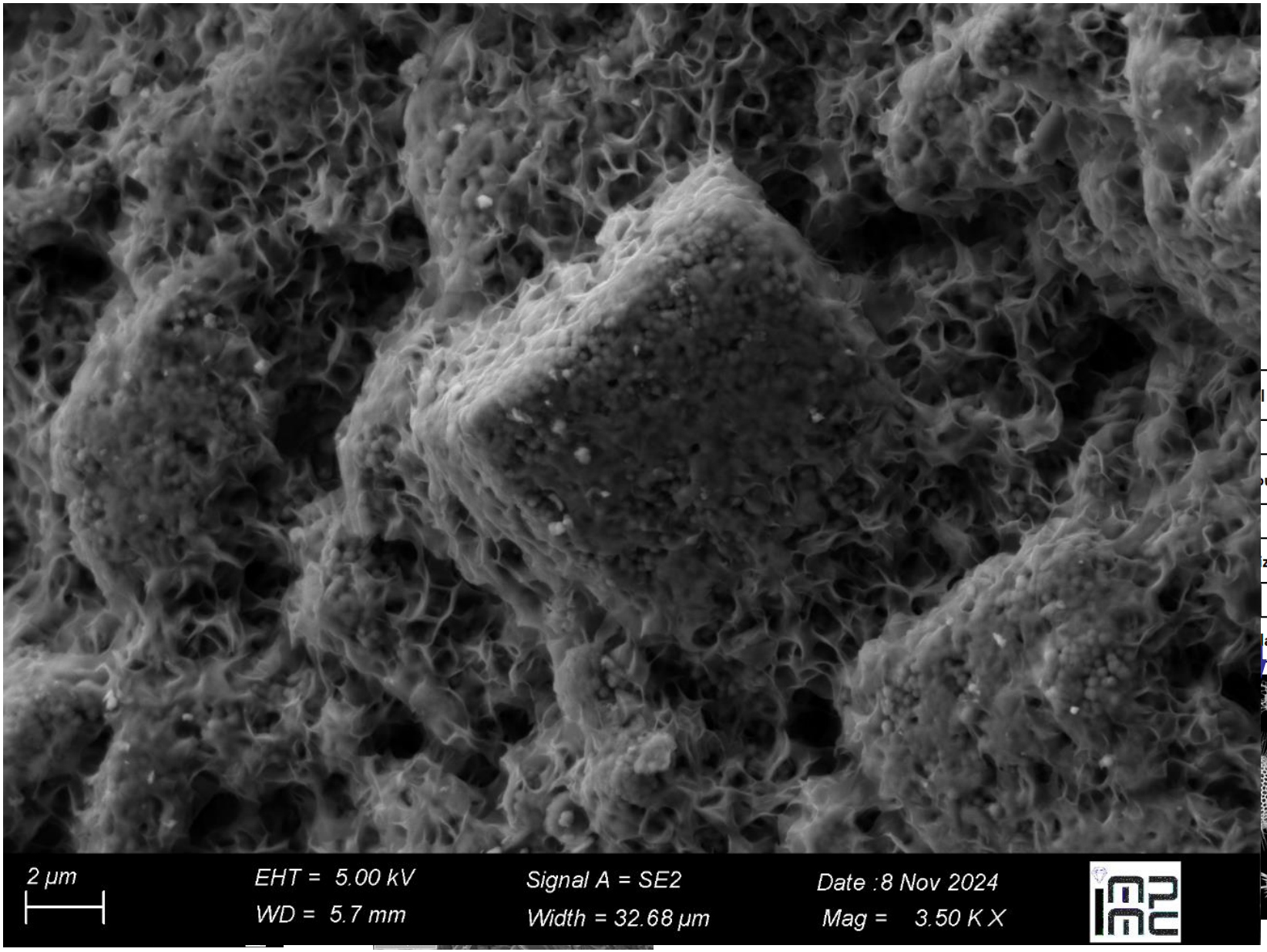


Past and current SCM'S

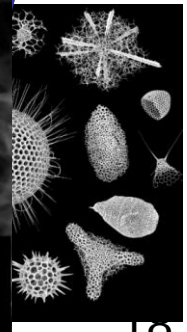


l sediment

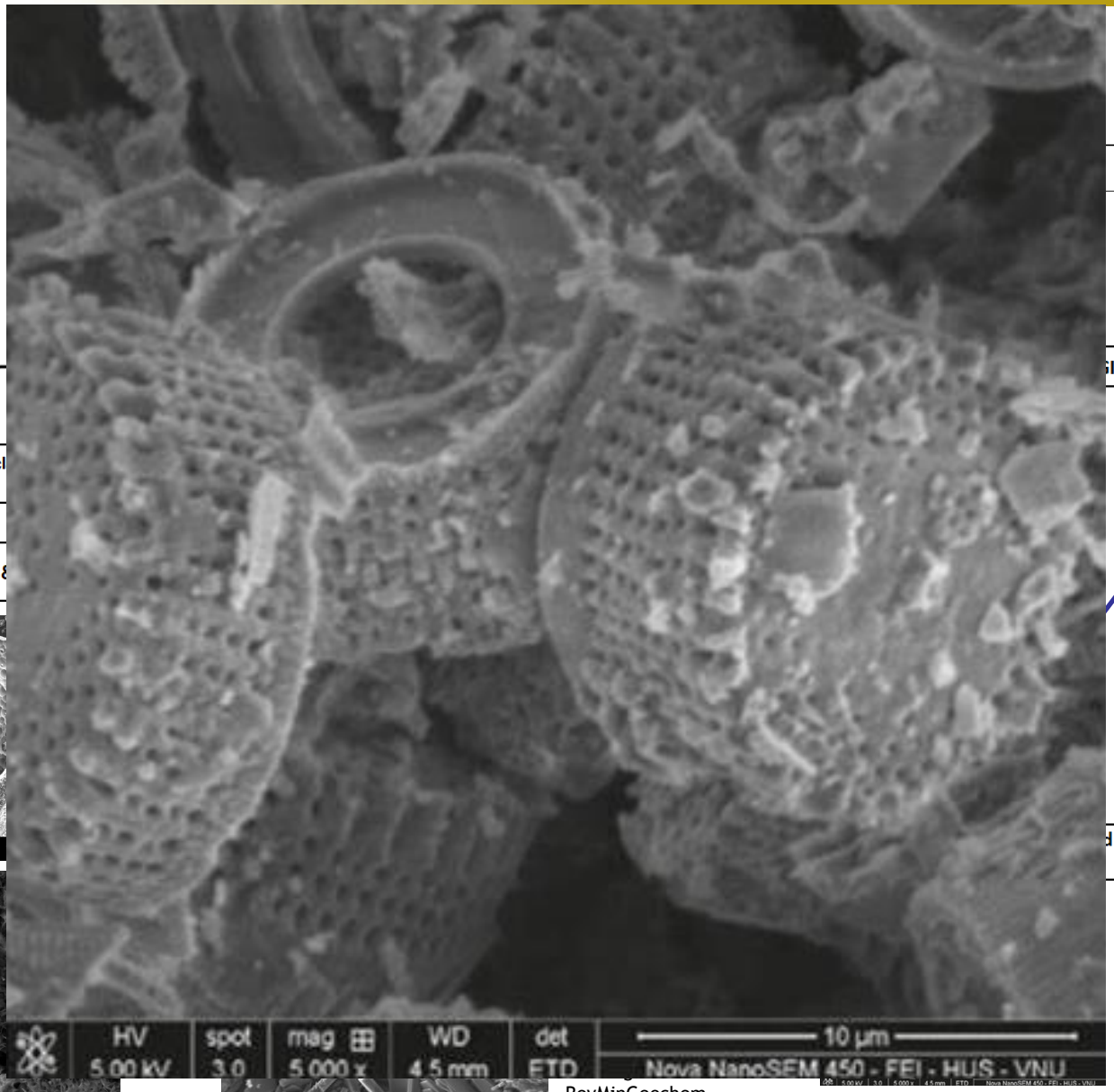
us earth

ze

larite

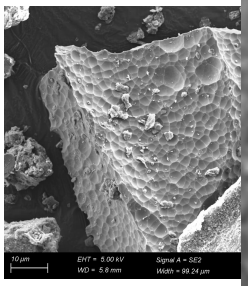


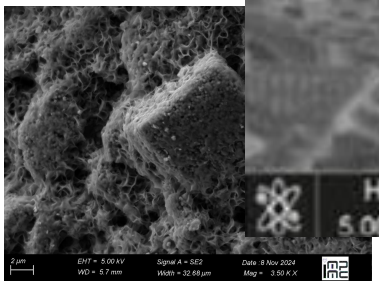
Past and current SCM'S

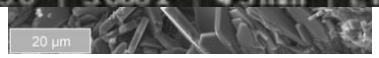


Unaltered pyrocl
materials

Vitreous pumices &







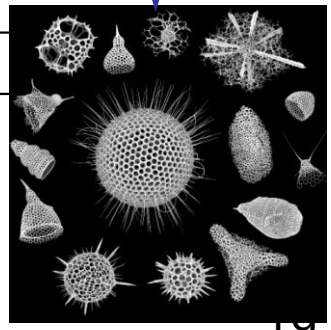
IN

detrimental sediment

Diatomeous earth

Gaize

Radiolarite



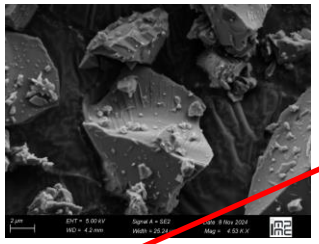
Emerging SCM'S

Blast Furnace slag | Fly ash (V, W) | Silica Fume | Burned organic matter residue | Burned clay/shale } Primary

ARTIFICIAL SCMs

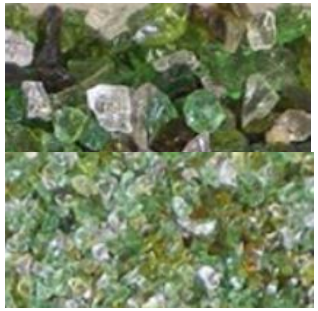
Scrap iron/non-ferro industry slag | Bottom ash Municipal solid waste ash | Waste glass | Recycled Concrete Fine | Fluid cracking catalyst residue } Secondary (Recycled)

Not recognized in EN 197-1 & -5



Izoret & Estève 2024

Argiz et al 2017

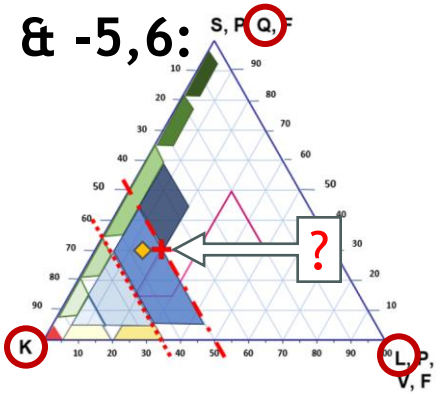


Izoret / France Ciment 2023

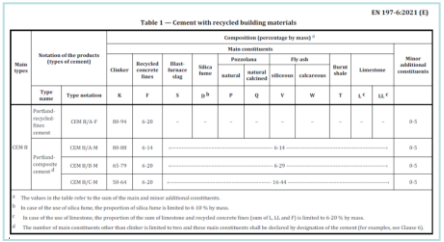
→ EN197-6

How to legally use these emerging SCM's ?

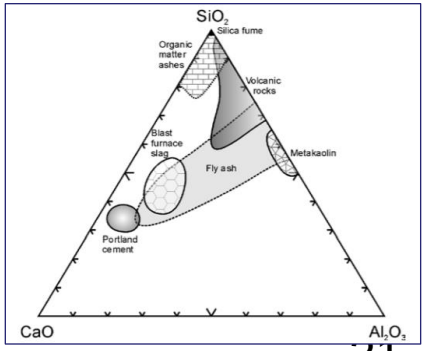
- The best way is standardization: composition-based cement standard EN197-1
- 3 main limitations from the structure of EN 197-1 & -5,6:
  - Too rigid composition limits unable to manage innovation



  - Extremely limited ability of composition table (Table 1) to incorporate new materials
    - How to incorporate potentially infinite list of materials?
    - How to label these materials?
    - How to give a clear vision to producers and end-users?



  - Inability to properly dose multiple similar constituents to track certified compositions; e.g. Calcined clay in cement



How to deal with emerging SCM's ?

Concrete yesterday ≠ Concrete today ≠ Concrete tomorrow

What we have → Construction standards that secure the past

What we need → Construction standards that prepare for the unknown future

- Bi-univocal relationship between the material and its method of manufacture
- Assessment scheme based on knowledge and performance-based approach

How to switch from a compositions-based to a performance-based standardization?

How to deal with these new SCm's

This is required from CPR point of view and its current revision :

- BRCW1 (*Mech. Strength and stabili*),
- BRCW3 (*impact of cement on healt and environment*)
- BRCW7 (*use of sustainable resourc*)

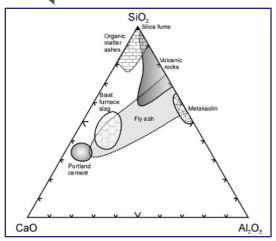
TC-PHC & TC-EBD

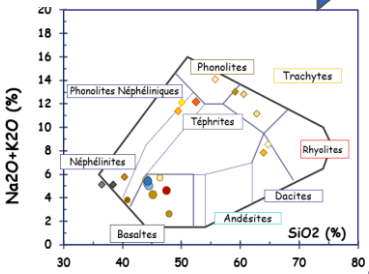
- **Joint recommendation**
  - Draft standards
  - Draft procedure

Comparison and performance-based logics

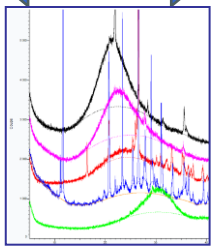
1st proposal : a two-step procedure

SFX → DRX → R3 tests

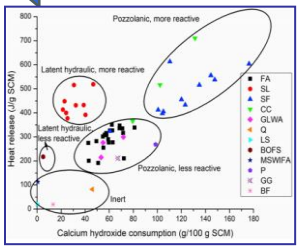




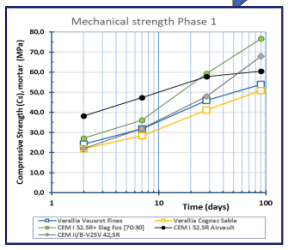
Snelling et al. RMG 2012



Serbource et al. CCR 2024



Suraneni et al. CCC 2019

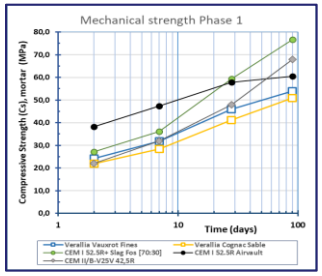


Izoret 2023

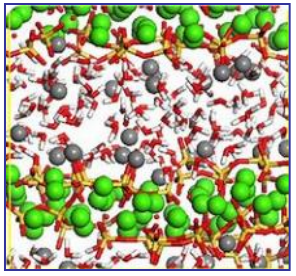
New constituent, no RoE

- Type of hydraulicity (hydraulic, latent, pozzolanic, inert)
- Intensity of reactivity

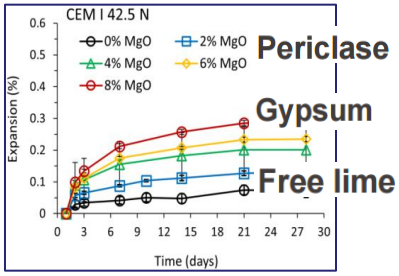
- Cement formulation (smart)
- Performance testing



Strength development pattern



Minimum C-S-H content

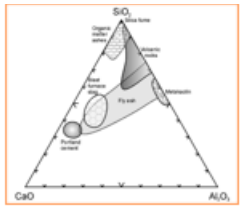


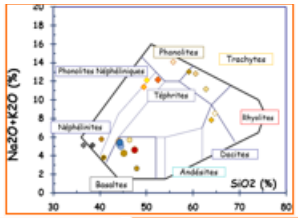
Internal stability

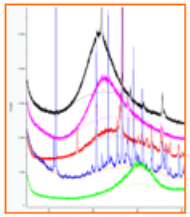
Durability

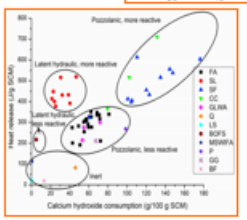
Comparison and performance-based logics

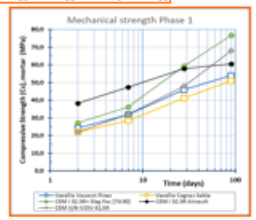
Material (SCM)











BRCW1

Ni, Co, Cr/ Cr6+

BRCW3

Classification by type of behaviour
(link with table 1 EN197-1)
e.g. H, LH, P, I

1

Constancy of performance

Fitness for use e.g. XC3, XF1, …

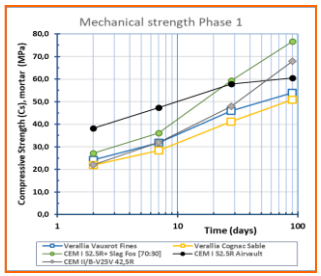
If integrated into the quality control chain at cement plant level

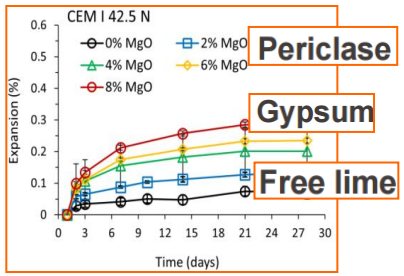
CERTIFIED

New constituent, no RoE

Formulated cement

PSD (non-nano)
RCS
i-index
Ni, Co, Cr/ Cr^{6+}
Leaching tests





Cl- diffusion
ESR
Carbonation

TC 298-EBD

TC-PHC & TC-EBD

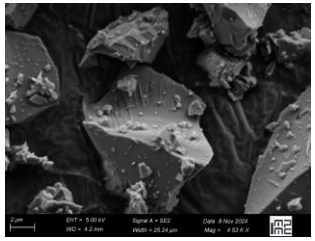
BRCW3

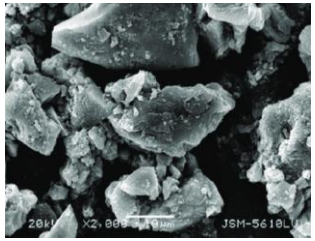
2

BRCW1

A possible future for European Standardization

New SCMs materials





Safe & Legal use:

- By design
- By control
- By Standards

Réseau Réciproque Conseil

Thank you for your attention