ISPRA
Istituto Superiore per la Protezione e la Ricerca Ambientale

POLITECNICO DI MILANO

MAPEI

REMEDIATION AND REUSE OF CONTAMINATED SEDIMENTS: A NEW PHYSICAL-CHEMICAL PROCESS TO THE POINT

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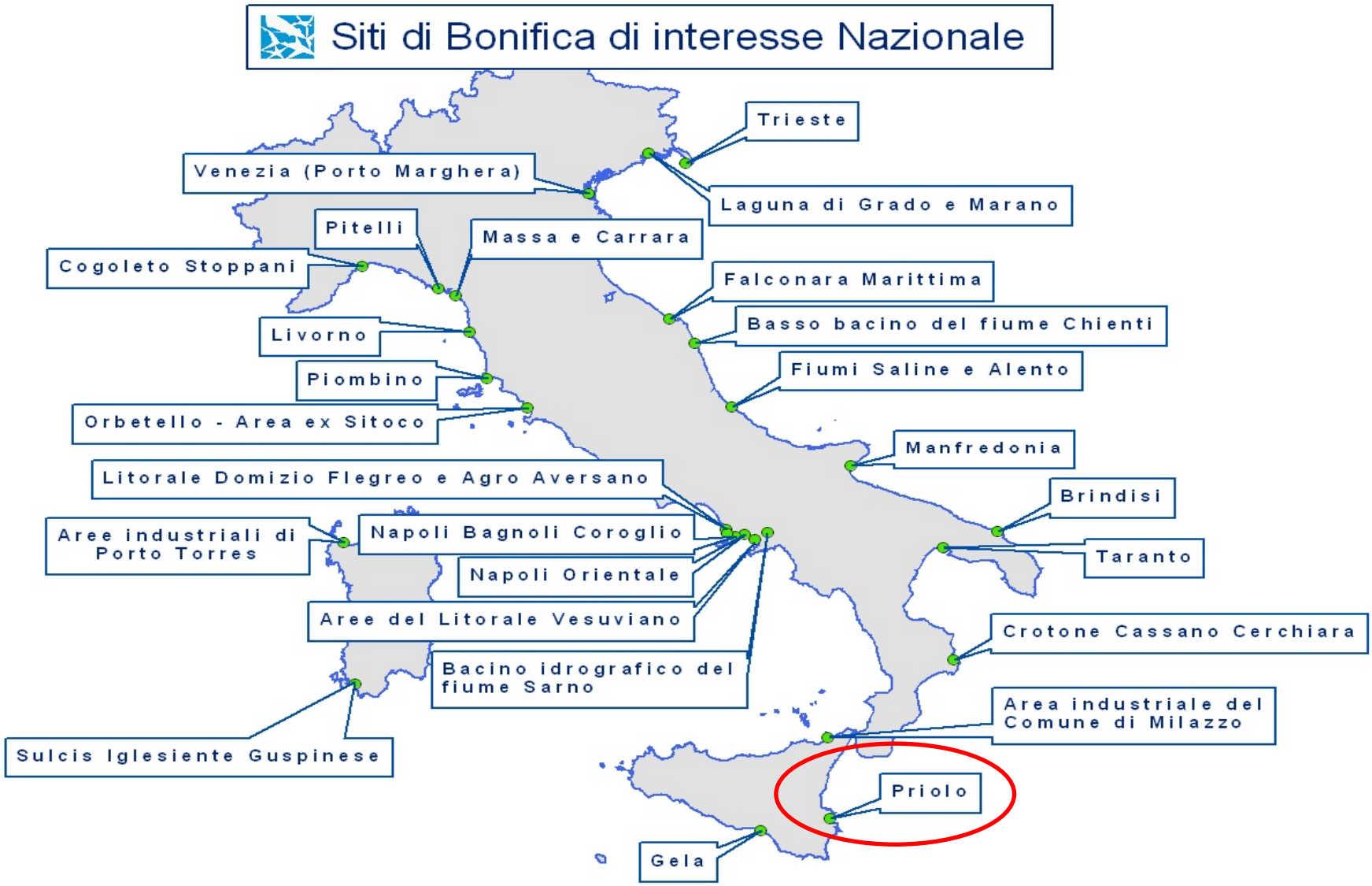
2nd International Workshop: Mechanism and Modelling of Waste/Cement Interactions
Le Croisic, October 12-16, 2008 october 2008


Siti di Bonifica di interesse Nazionale
Trieste
Venezia (Porto Marghera)
Laguna di Grado e Marano
Pitelli
Massa e Carrara
Cogoleto Stoppani
Falconara Marittima
Basso bacino del fiume Chienti
Livorno
Fiumi Saline e Alento
Piombino
Orbetello - Area ex Sitoco
Manfredonia
Litorale Domizio Flegreo e Agro Aversano
Brindisi
Aree industriali di Porto Torres
Napoli Bagnoli Coroglio
Taranto
Napoli Orientale
Aree del Litorale Vesuviano
Crotone Cassano Cerchiara
Bacino idrografico del fiume Sarno
Area industriale del Comune di Milazzo
Sulcis Iglesiente Guspinese
Priolo
Gela

Analytical results of most contaminated sediment selected for this work (600.000 m³)

Compound	Concentration (mg/kg d.w.)			
Chromium (total)	91			
Copper	210			
Nickel	22			
Lead	51			
Zinc	314			
Arsenic	18			
Cadmium	1			
Mercury	200			
HCB	0,003			
PAH (total)	5			
PCB (total)	3			
>C12 petroleum hydrocarbons	5 000	-	750	1 000
PCDD/F	$2{,}8 \cdot 10^{-4}$	$0{,}3 \cdot 10^{-4}$	$1 \cdot 10^{-4}$	$1 \cdot 10^{-2}$
TBT	0,003	0.07	-	2 500

Ordinary Solidification/Stabilization (S/S) processes aims at encapsulating wastes into a solid cement matrix (Solidification) and decreasing mobility and toxicity of inorganic contaminants (Stabilization)

Poor attention has been paid in the past to impart to S/S materials good mechanical properties in a form which could allow their reuse. The reason for this is that, in Italy, S/S process has been normally used to reduce leaching before landfill disposal.

THE OBJECTIVE OF THIS STUDY IS TO EVALUATE THE EFFICIENCY OF A NEW PHYSICAL-CHEMICAL PROCESS FOR THE TREATMENT OF LARGE VOLUME OF CONTAMINATED SEDIMENTS FROM AUGUSTA BAY

REUSE OF RESULTING S/S MATERIAL

MAPEI HPSS SYSTEM

High Performance Solidification/Stabilization

2 STEPS

first step: production of a cementitious granular material, based on principles of high performance concrete (HPC)

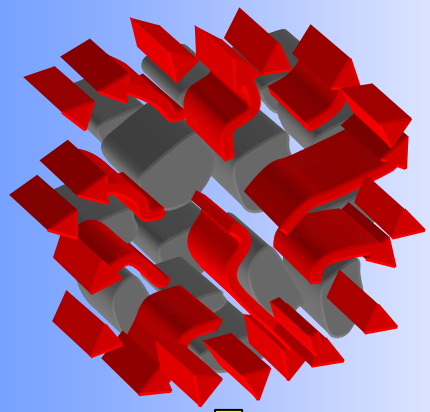
☺ use of superplasticizers and hydrophobic additive to reduce W/C and to improve watertightness

⇨ Environmental aspect

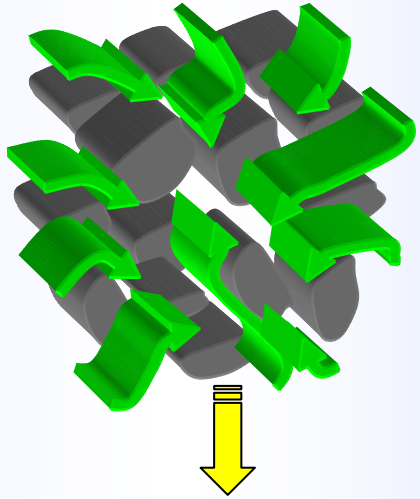
⇨ Service life

⇨ Mechanical properties

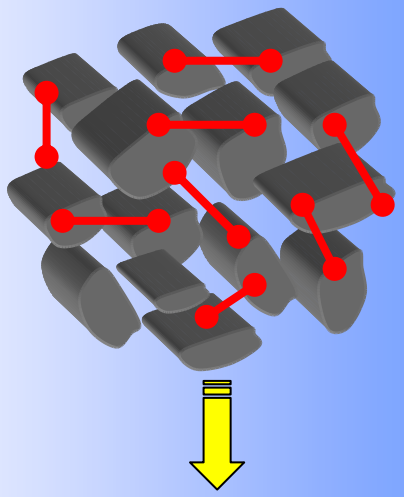
LOWER W/C AND HIGHER WATERTIGHTNESS MEANS



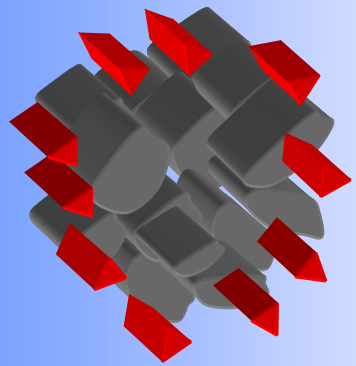
Lower leaching of contaminants



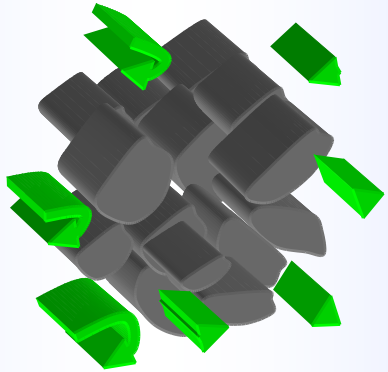
Lower permeability



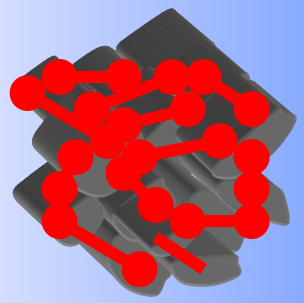
Stronger bonds



HIGHER ENVIRONMENTAL COMPATIBILITY



HIGHER DURABILITY



HIGHER MECHANICAL STRENGTH

First step: granulation

High shear mixer

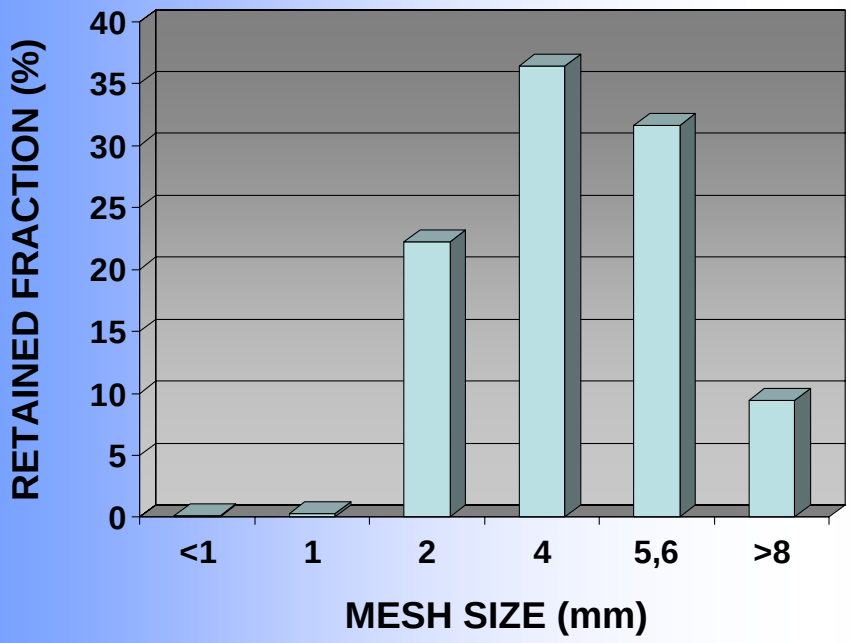
Rotating plate

Formulation:

- Augusta harbour sediment (60%, dry basis)
- Cement (CEM I, 52.5) (21%)
- Additives: Mapeplast ECO 1-A e ECO 1-B (2 %)
- Water (17%)

W/C = 0.8

W/C+S = 0.2



TYPICAL PARTICLE SIZE DISTRIBUTION OF GRANULAR MATERIAL FROM STEP 1

First step: granulation

INDUSTRIAL PLANT
CAPACITY 4m³/h

MAPEI HPSS SYSTEM

High Performance Solidification/Stabilization

2 STEPS

Second step: thermal vacuum distillation (TDV) of the granular materials from step 1. It is necessary when soil or sediments contain organic/volatile/semivolatile contaminants.

☺ Low temperature distillation (max 250 °C) under high vacuum (≤20 mm Hg)

⇨ No degradation of cement matrix

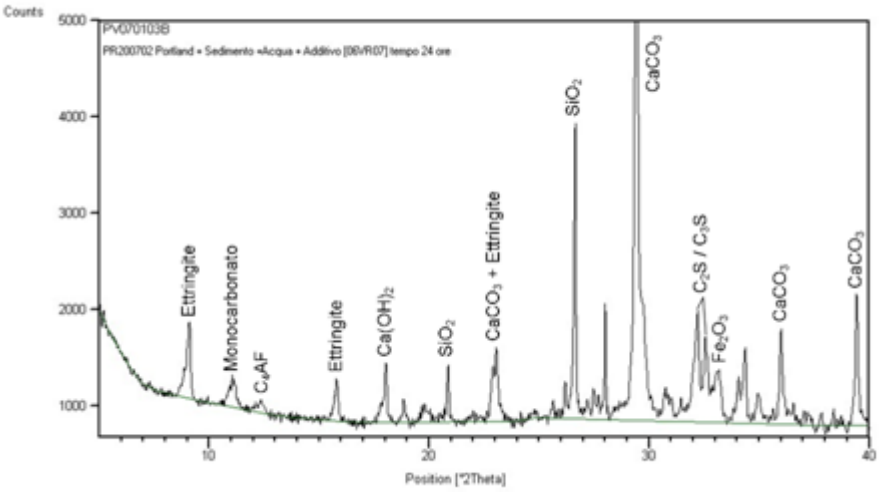
⇨ No gas emissions because the process is operating in high vacuum conditions

⇨ No dust problems because the process is operated on the granular materials

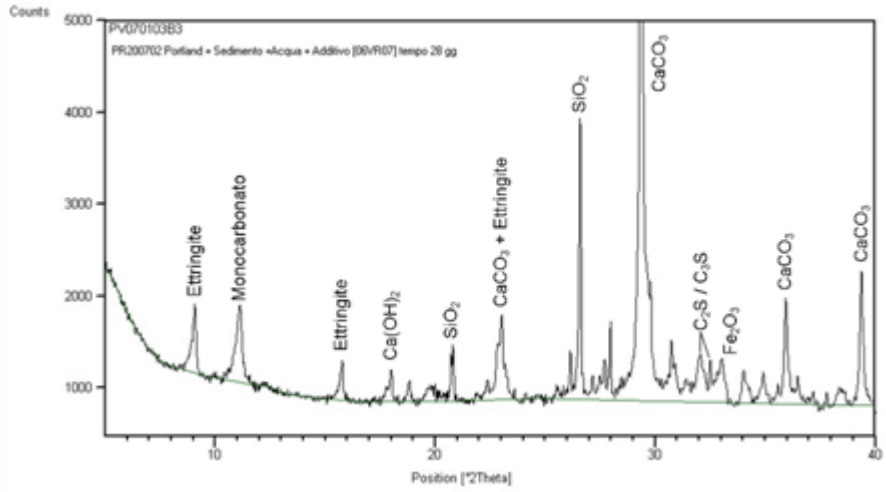
THERMAL VACUUM DISTILLATION EQUIPEMENTS

LAB SCALE (LEFT) – PILOT SCALE (RIGHT)

FISRST STEP - CEMENT HYDRATION



XRD after 24 hours

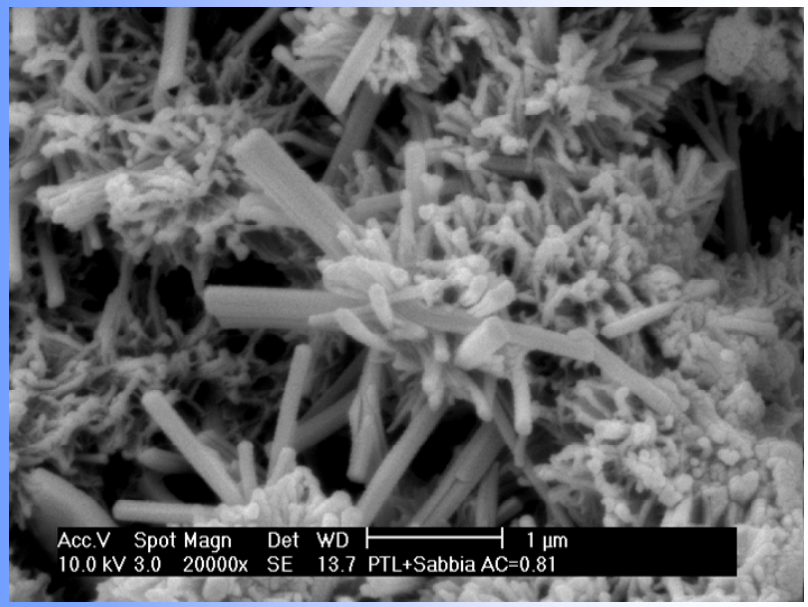


XRD after 28 days

- **no negative effect of sediment on set and hydration rate**
- **portlandite consumption**
- **monocarbonate formation**

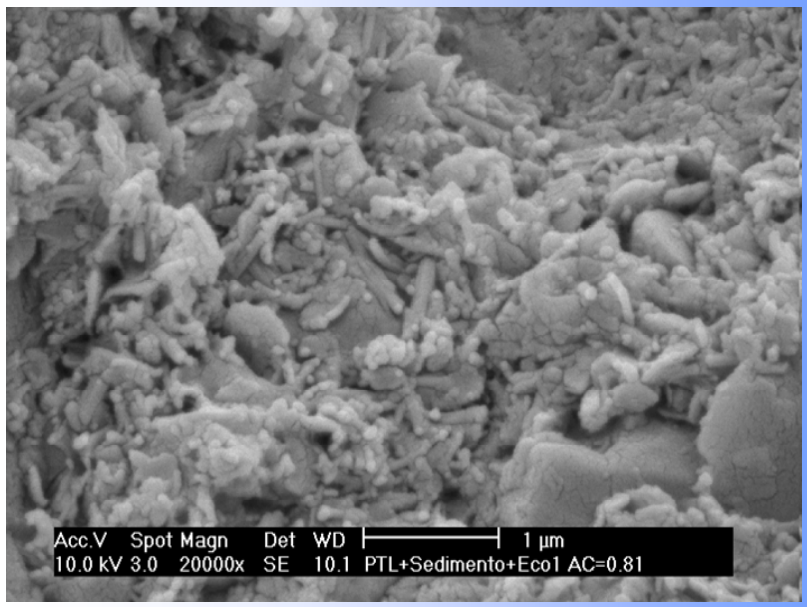
FISRST STEP - CEMENT HYDRATION

ESEM images after 24 hours of hydration



Fine quartz sand mortar

W/C = 0.8

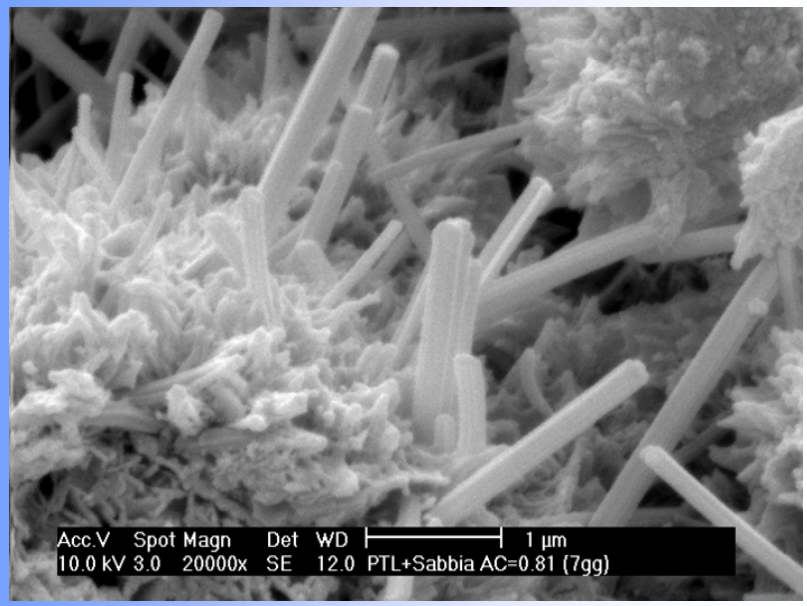


Sediment based granular material

W/C = 0.8

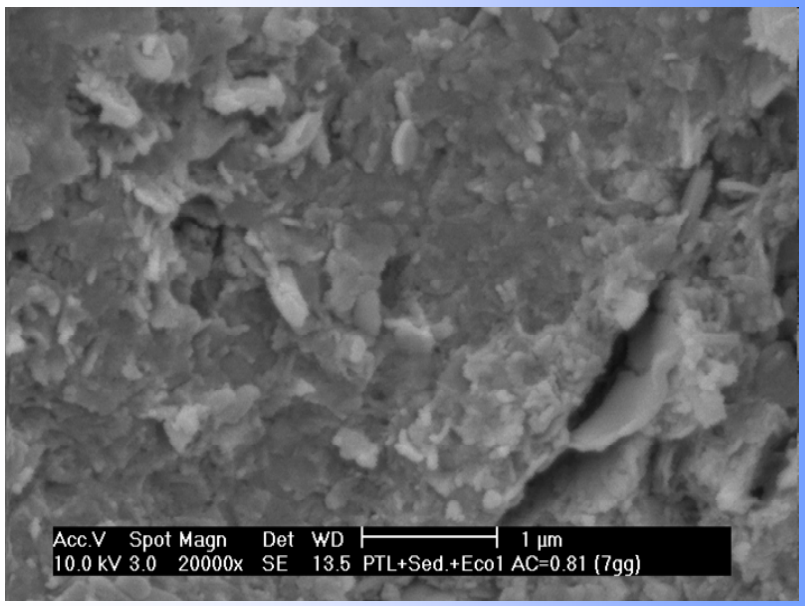
FISRST STEP - CEMENT HYDRATION

ESEM images after 7 days of hydration



Fine quartz sand mortar

W/C = 0.8

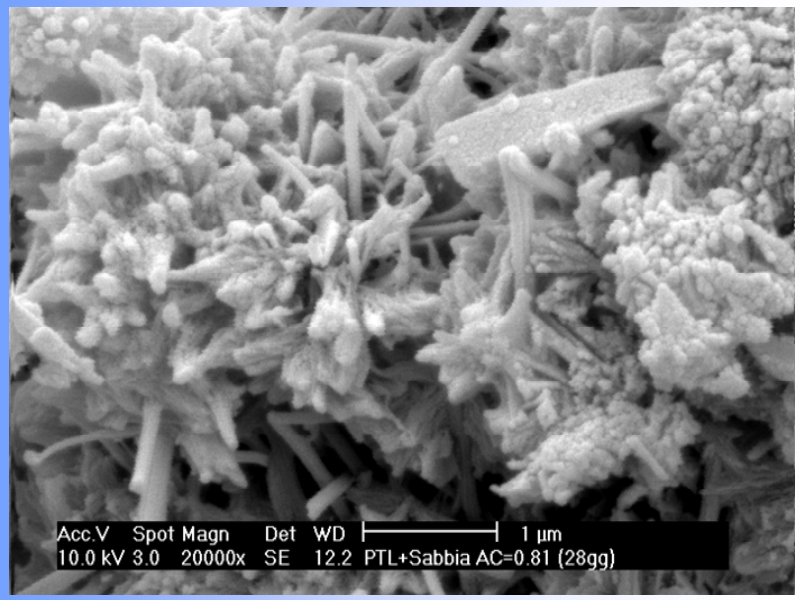


Sediment based granular material

W/C = 0.8

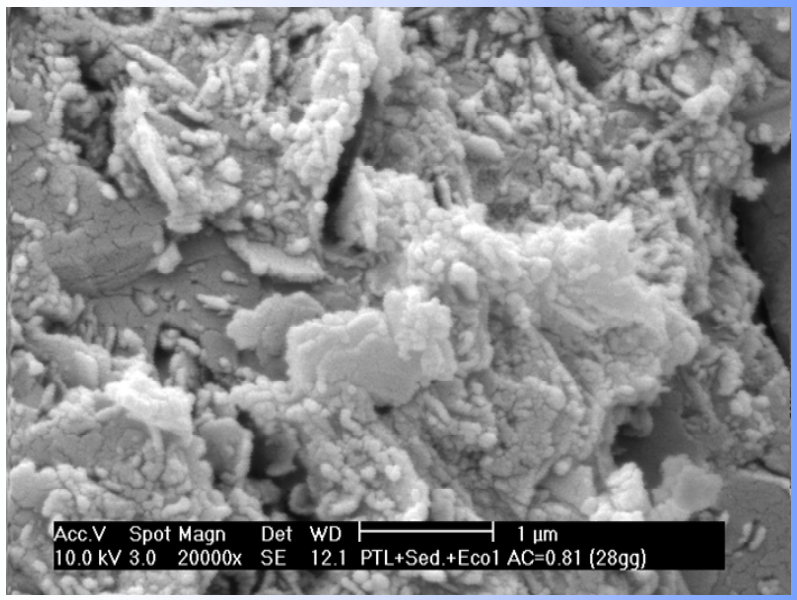
FISRST STEP - CEMENT HYDRATION

ESEM images after 28 days of hydration



Fine quartz sand mortar

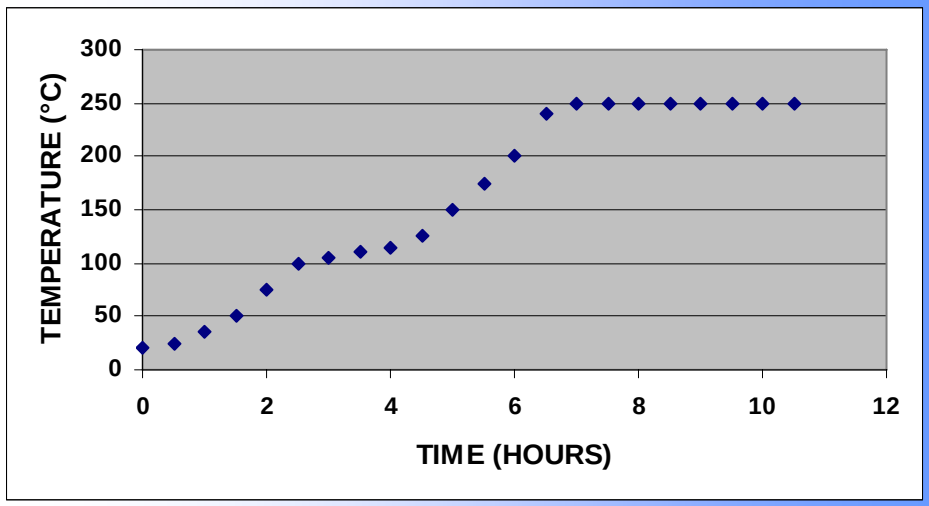
W/C = 0.8



Sediment based granular material

W/C = 0.8

SECOND STEP: THERMAL VACUUM DISTILLATION TVD



Evaluation of three different conditions ⇒ development process parameters

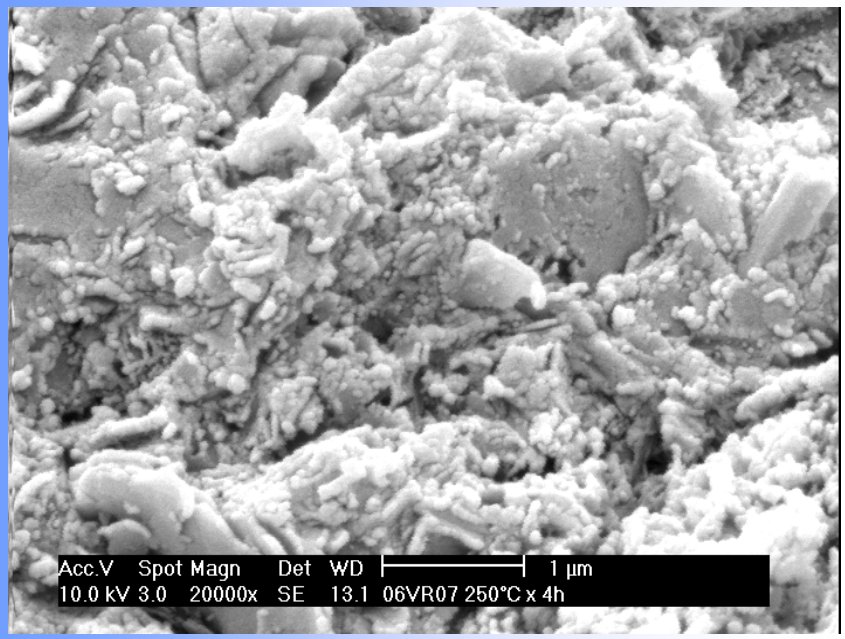
1. Temperature = 150 °C and $t_{residence}$ = 16 hours;

SELECTED CONDITIONS: 250 °C FOR 4 HOURS

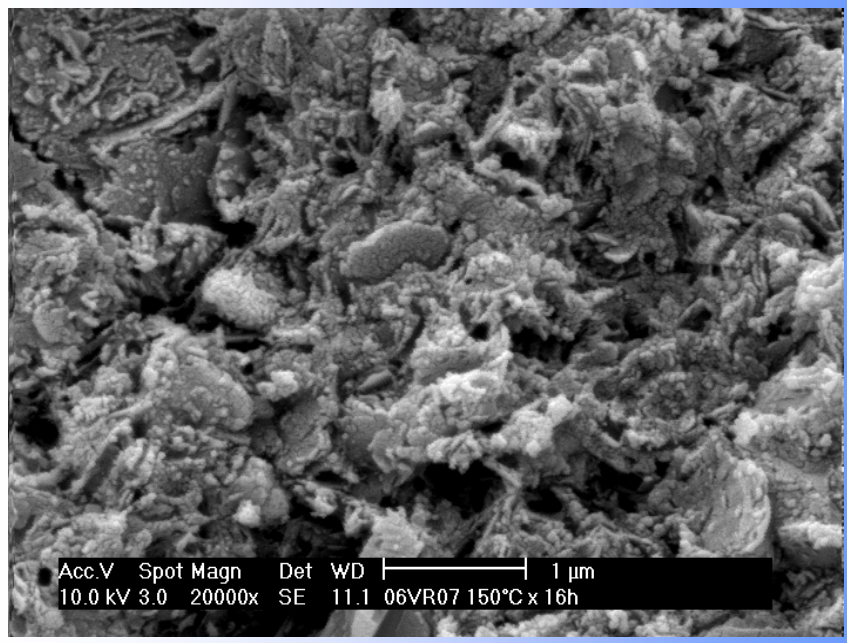
3. Temperature = 250 °C and $t_{residence}$ = 4 hours.

SECOND STEP: THERMAL VACUUM DISTILLATION TVD

Results of morphological analysis



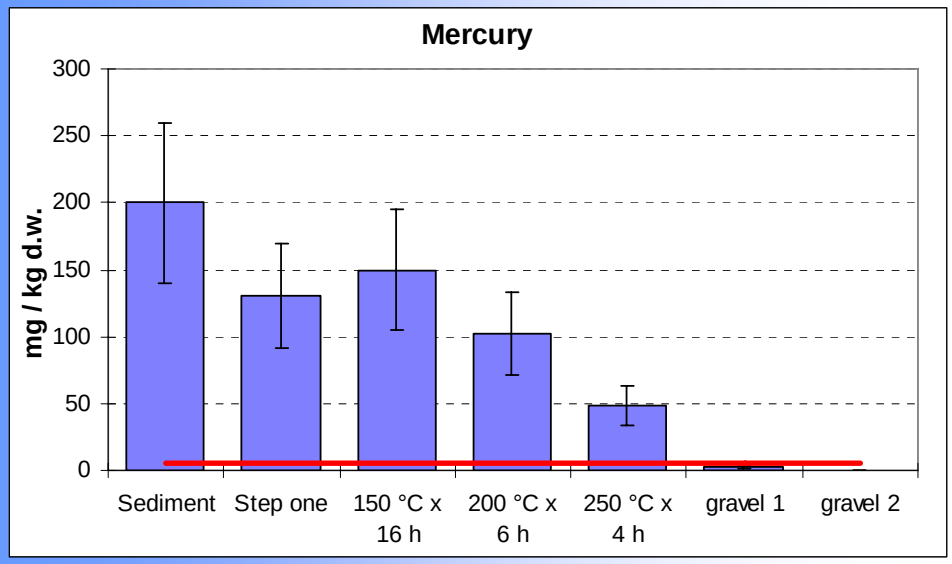
250 °C, 4 hours

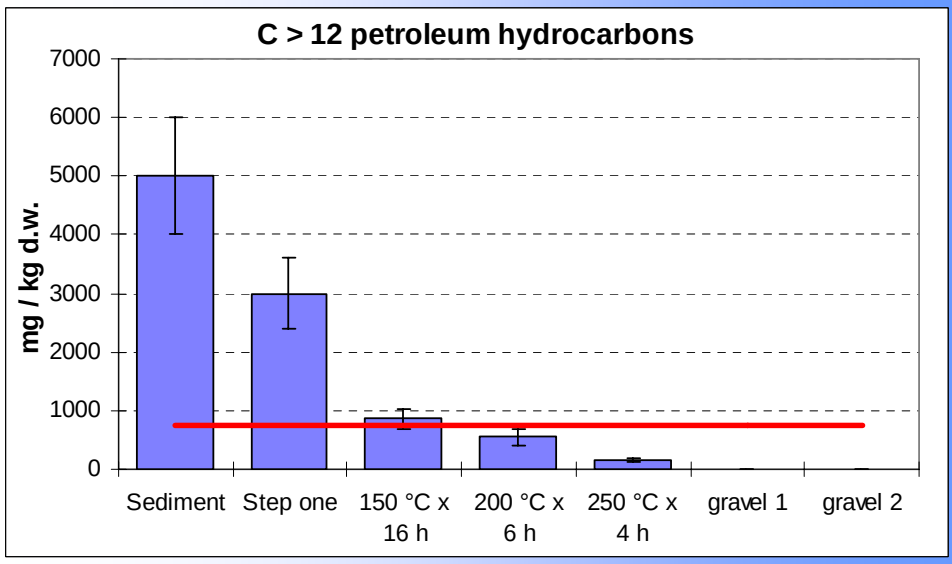


150 °C, 16 hours

SECOND STEP: THERMAL VACUUM DISTILLATION TVD

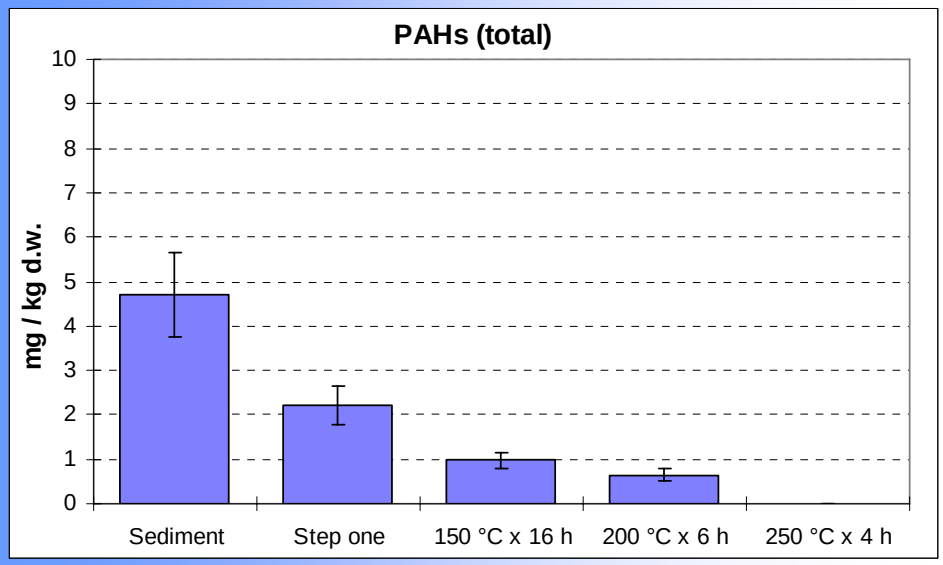
Results of chemical analysis (1/3)

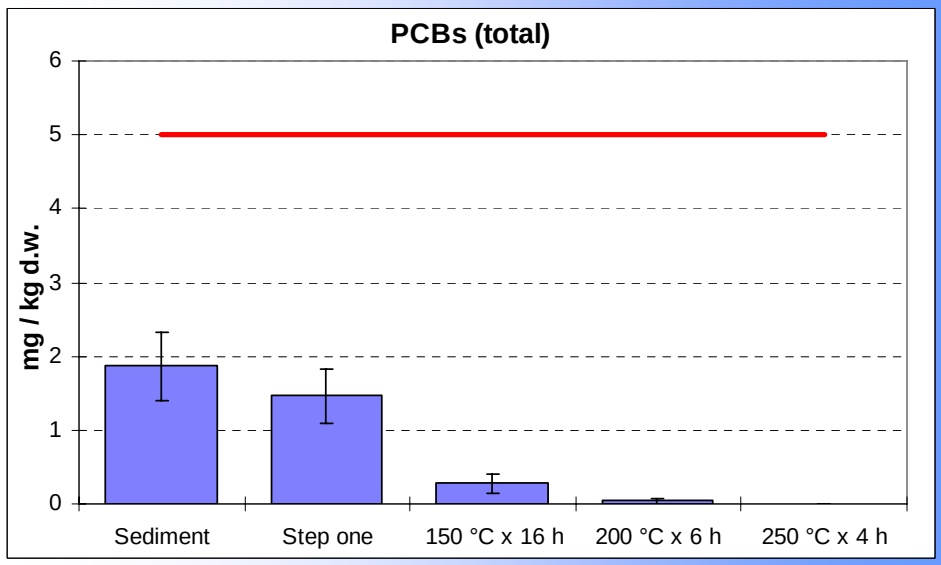




SECOND STEP: THERMAL VACUUM DISTILLATION TVD

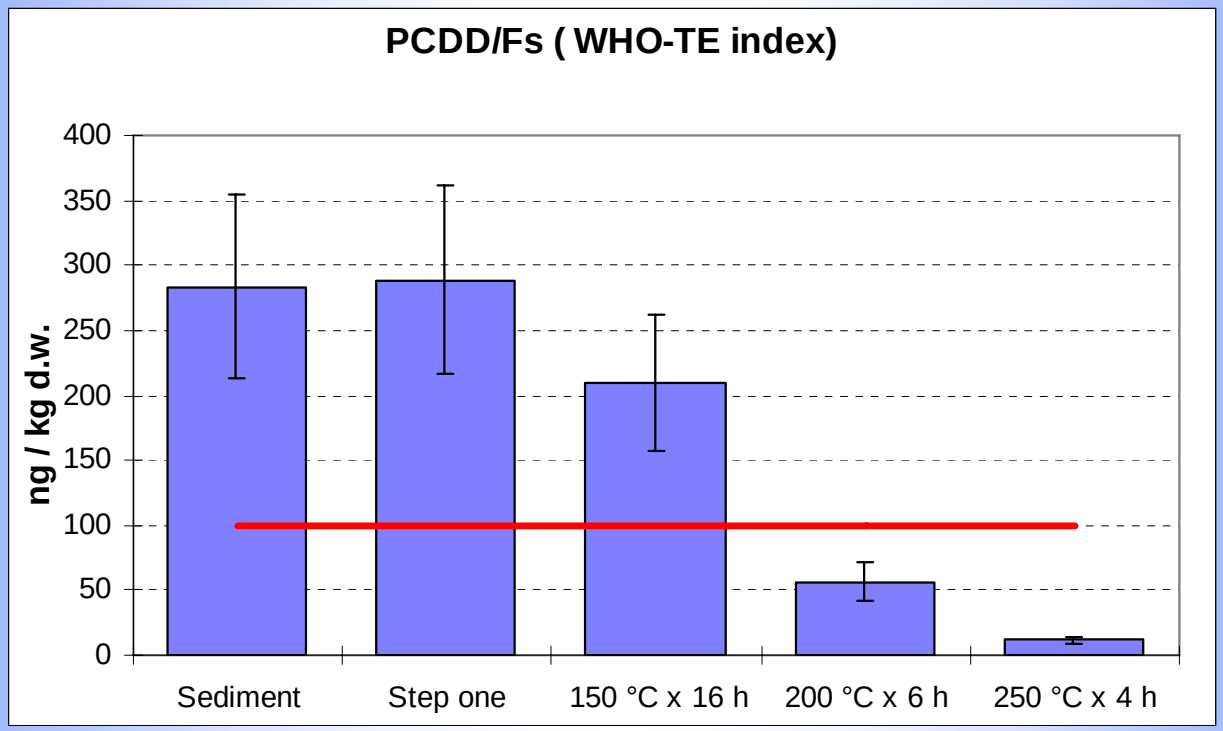
Results of chemical analysis (2/3)





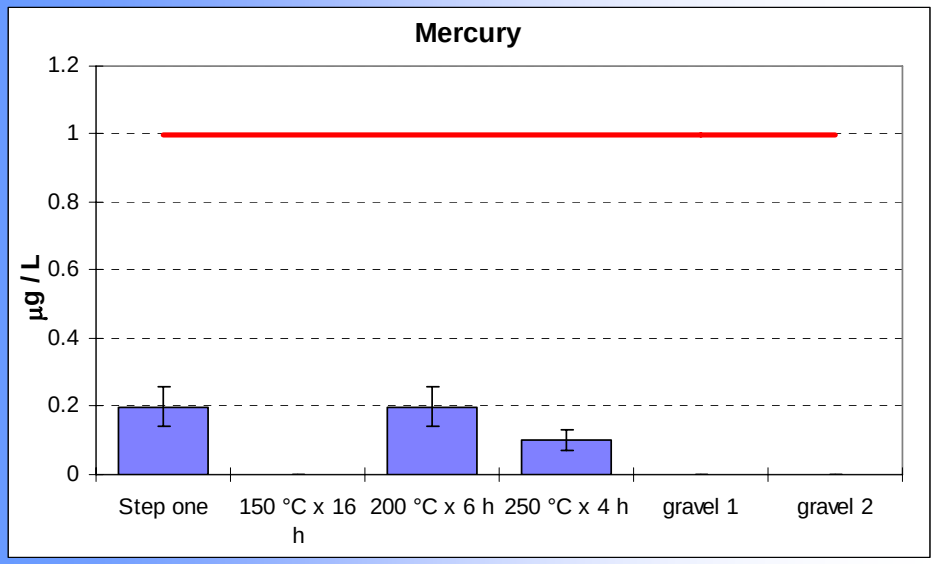
SECOND STEP: THERMAL VACUUM DISTILLATION TVD

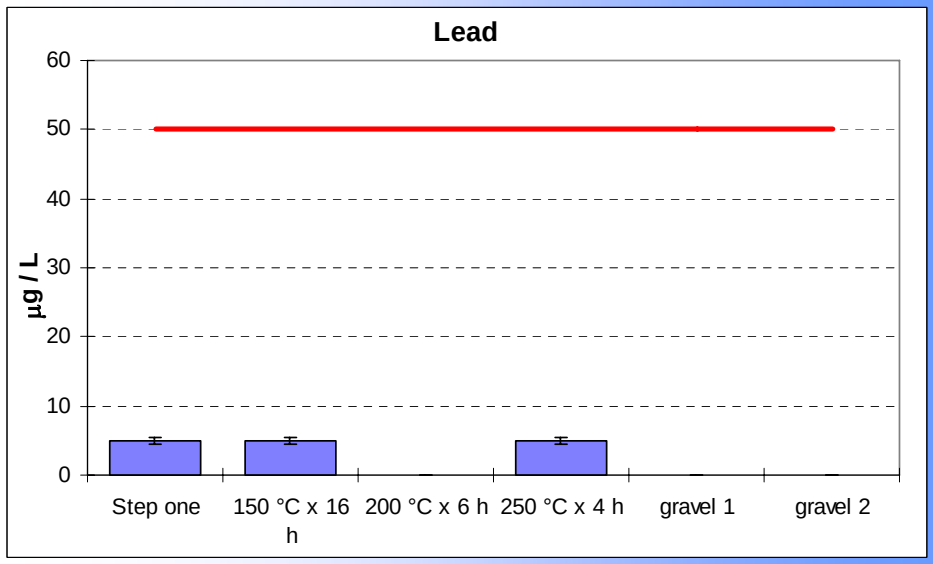
Results of chemical analysis (3/3)



SECOND STEP: THERMAL VACUUM DISTILLATION TVD

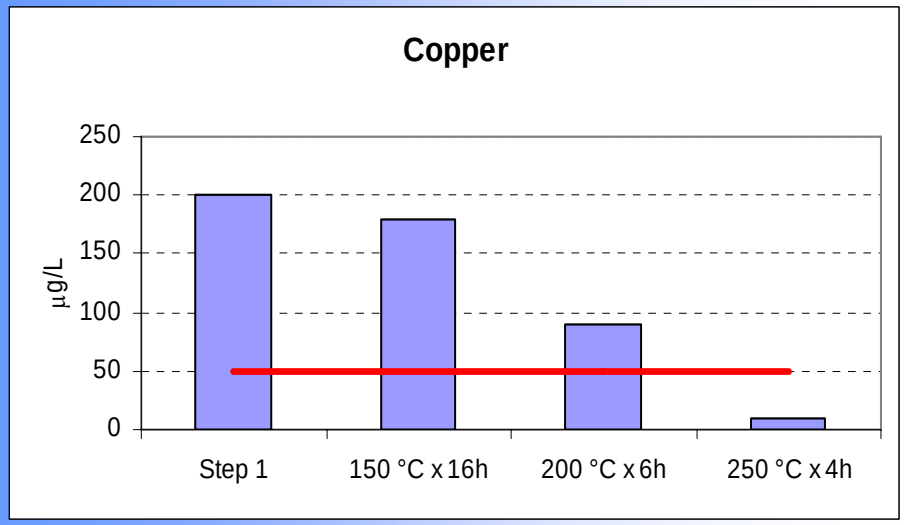
Results of leaching test (EN 12457-2)

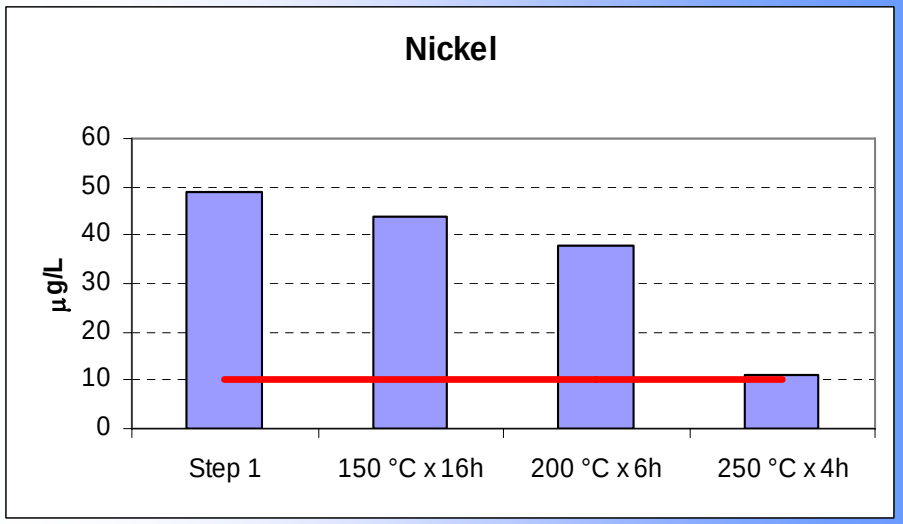




SECOND STEP: THERMAL VACUUM DISTILLATION TVD

Results of leaching test (EN 12457-2)

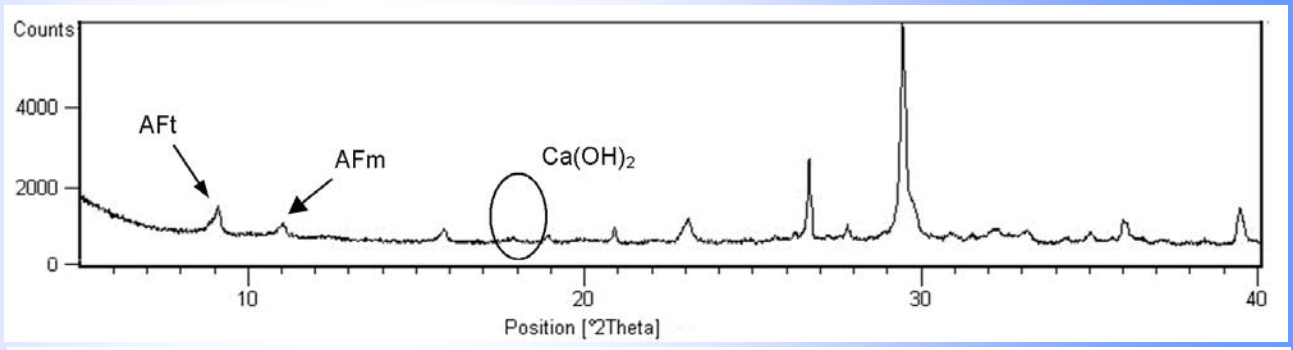




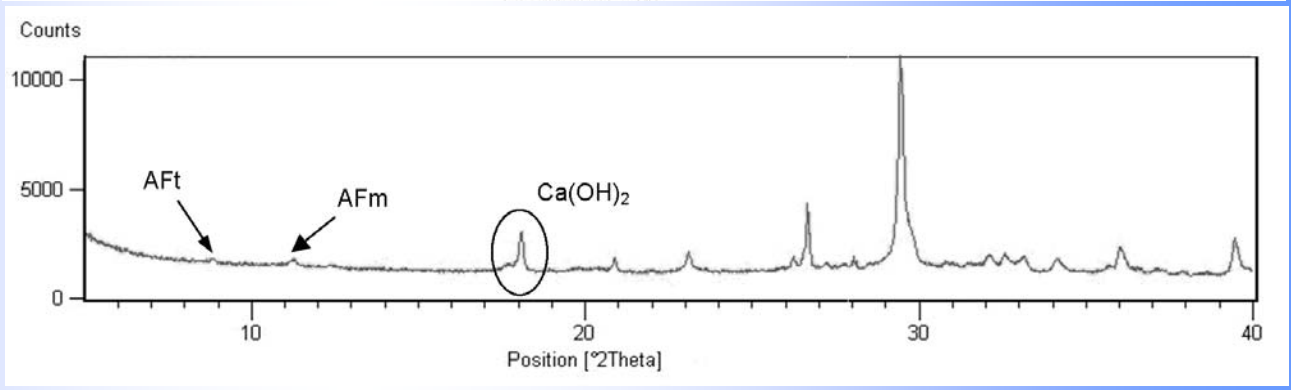
Identified problems:

- pH value too high (13) – conditioning step in water
- Chlorides
- Selenium

BEFORE VTD

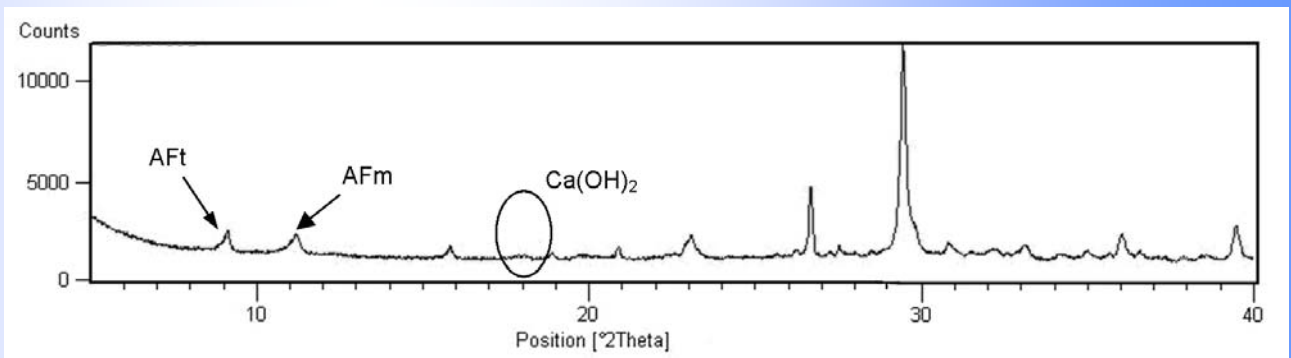


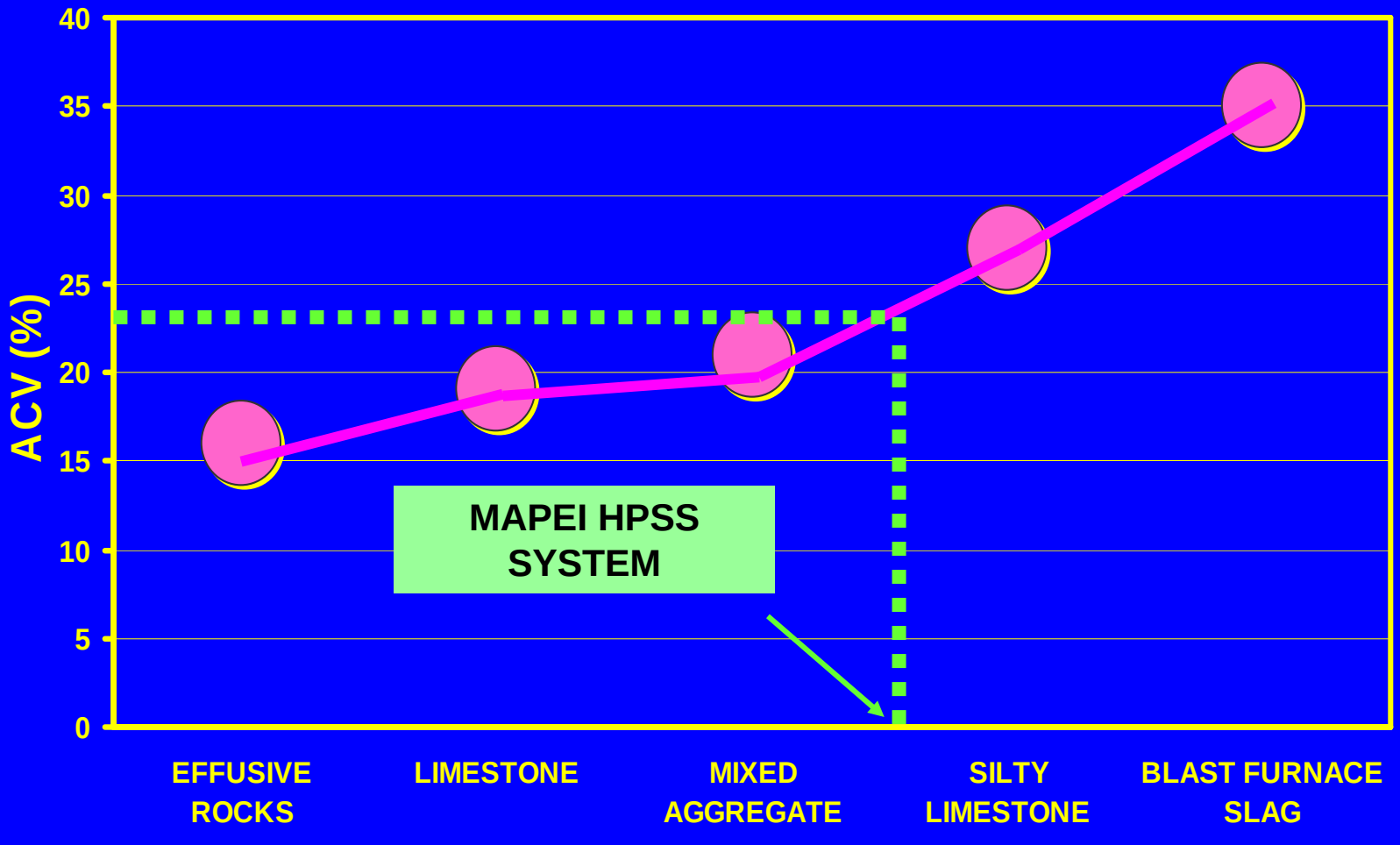
AFTER VTD (250 °C FOR 4 HOURS)



CONDITIONING STEP IN WATER FOR 7 DAYS

AFTER REHYDRATION




40
35
30
25
20
15
10
5
0
ACV (%)
MAPEI HPSS SYSTEM
EFFUSIVE ROCKS
LIMESTONE
MIXED AGGREGATE
SILTY LIMESTONE
BLAST FURNACE SLAG
TYPE OF AGGREGATE

CONCLUSIONS (1/2)

1. **MAPEI HPSS TREATMENT WAS EFFECTIVE IN STABILIZING INORGANIC AND REMOVING VOC AND SVOC WHEN APPLIED TO MARINE SEDIMENT OF THE AUGUSTA HARBOUR (SICILY)**

2. **HYDRATION RATE WAS NOT AFFECTED BY THE SEDIMENT, BUT CHEMICAL INTERACTION BETWEEN CEMENT AND SEDIMENT WERE EVIDENT (PORTLANDITE CONSUMPTION, MONOCARBONATE FORMATION AND MORPHOLOGICAL MODIFICATION OF THE HYDRATED MATRIX)**

3. **THERMAL TREATMENT OF HYDRATED GRANULAR PRODUCTS HAD A POSITIVE EFFECT IN REDUCING THE LEACHING OF COPPER, NICKEL AND COBALT**

4. **THERMAL TREATMENT OF HYDRATED GRANULAR PRODUCTS DECOMPOSED AFt AND AFm PHASES BUT REHYDRATION IN WATER PROMOTE THEIR REFORMATION**

CONCLUSIONS (2/2)

5. **THERMAL TREATMENT OF HYDRATED GRANULAR PRODUCTS AT 250 °C DID NOT CAUSE THE DEGRADATION OF THE CEMENT MATRIX AND THE RESULTING PRODUCTS SHOWED GOOD MECHANICAL PROPERTIES FOR REUSE OPTION**

FUTURE DEVELOPMENTS

a. **Pollutants mass balance**

b. **More complete tests for physical and mechanical properties and durability (total porosity, Los Angeles, Micro-Devall, alkali-silica reaction, freezing-thawing) will be performed**

c. **pH dependent leaching tests and leaching column test**

d. **Speciation of mercury**

Thank you for your attention!!!