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Acid geopolymer materials based on different aluminosilicate sources

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Acid geopolymer materials based on different aluminosilicate sources

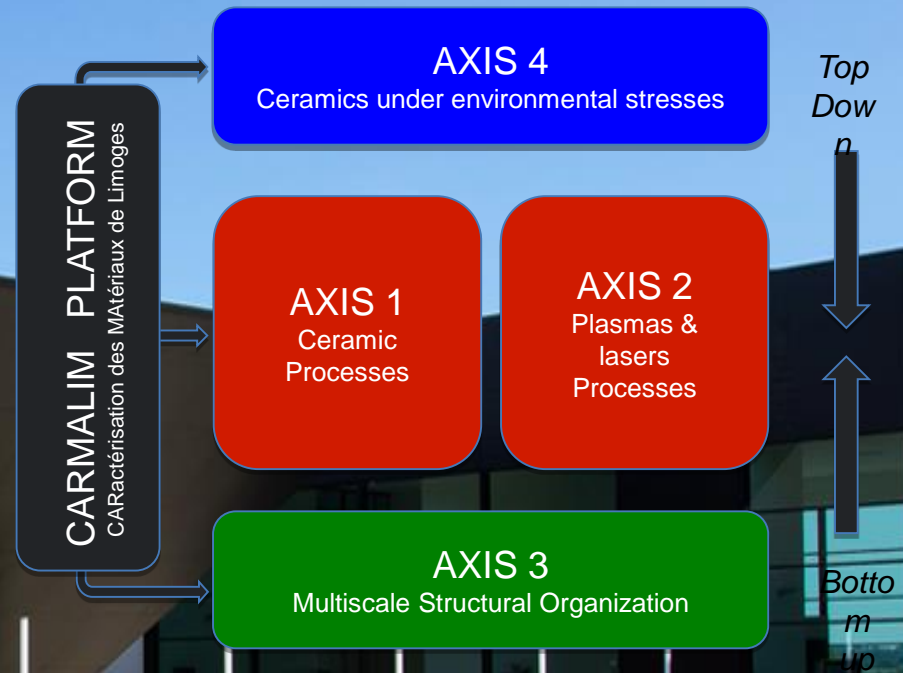
ROSSIGNOL Sylvie

with:

Hélène Célérier, Virginie Mathivet

Nicolas Tessier-Doyen, Jenny Jouin

IRCER
200 pers.
8200 m²



→ Comprehension / mastering of elaboration (ceramic processes and surface treatments) of real objects with new or improved properties

Context

Materials in drastic conditions



refractory



aerospace



⇒ Thermal behaviour, water resistant, mechanical properties?

Geopolymer binders

Synthesis:

Alkaline silicate solution



Dissolution of the mineral source



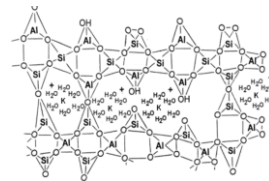
Oligomer formation (Si – Al)



Polycondensation



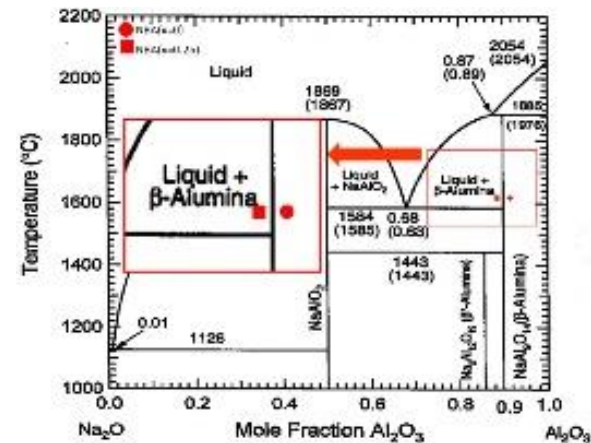
3D network (Na, K)



Use of alkaline prohibited
in presence of alumina as example



Degradation in temperature



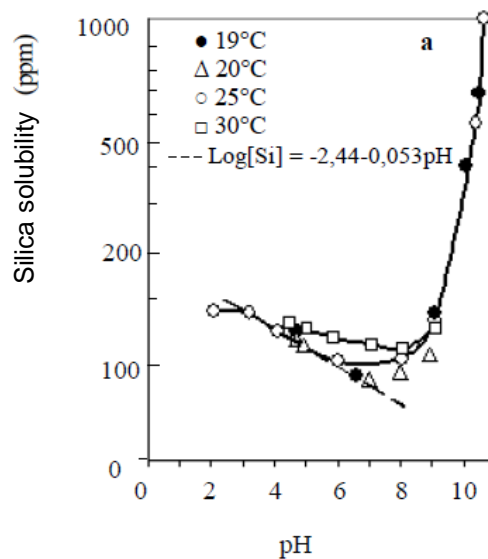
=

viscous flow

Necessary to change → choice of another way

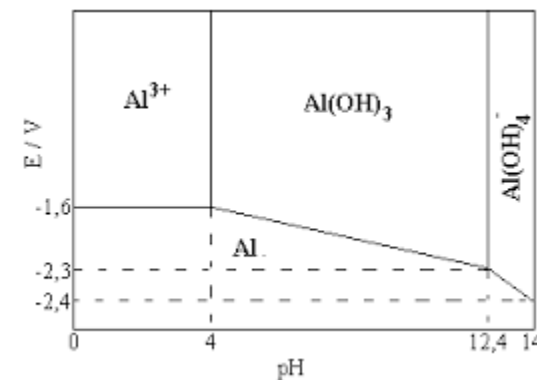
Aluminosilicate sources

Si species



Silica dissolution
only basic medium

Al species



Alumina dissolution
acid and basic medium

Difficulty in acid medium?

Previous works on acid geopolymer

Phosphoric source¹

Various concentration 4-12 M
Homogeneous samples

High compressive strength value to 10M

Disused phosphoric acid²

High compressive strength value = 67 MPa

Resistance in high temperature 1300°C

⇒ What happens in presence of several formulations and how to understand the chemical composition effect?

[1] H Tchakoué et al, applied clay science 147 (2017) 184-194

[2] C GuO et al, Ceramics International 42b(2016) 9287-9291

Aim and tools

Determination of the existence domain



Evaluation of the thermal and water resistance

- Identification of several compositions

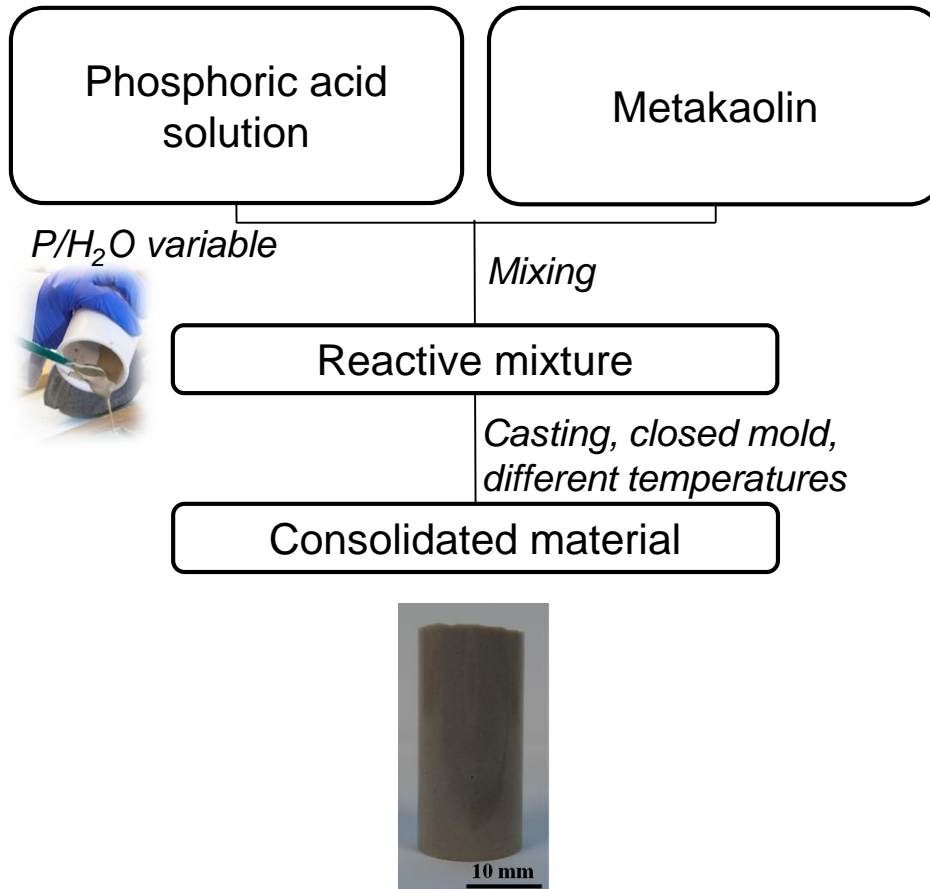


Characterization of the samples

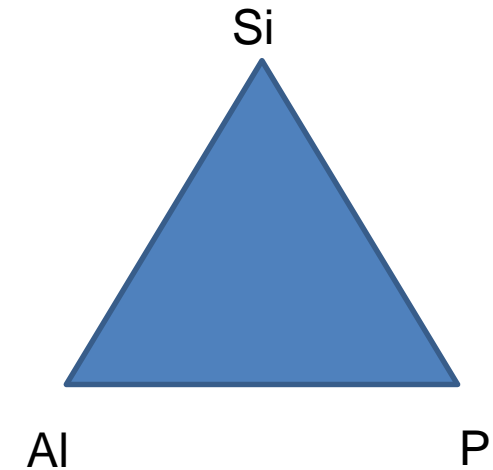
- Amorphous state
 - Water amount
- Mechanical behaviour

Samples preparation and identification

Protocol



Temperature 20 to 70°C
Various Al/P and Si/P



Different metakaolin
(M1, M3, M4)

Thermal resistant : 1000°C (1h)
Water resistant: 24h in water

Characterization methods

Evaluation after thermal and water resistance

Visual observations

- Presence and size of cracks

✓ good resistance



~ medium resistance

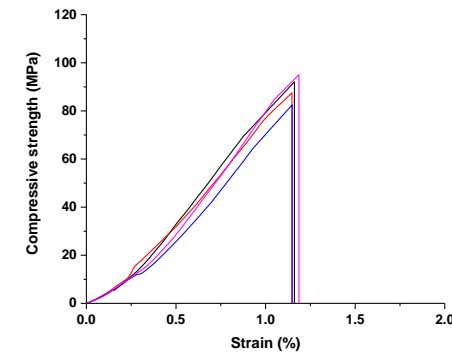
✗ lack of resistance



Compressive strength measurements

- Lloyd EZ20 apparatus

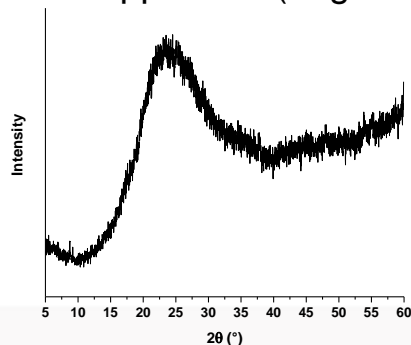
σ compressive tests



Characterization of the samples

X-ray diffraction

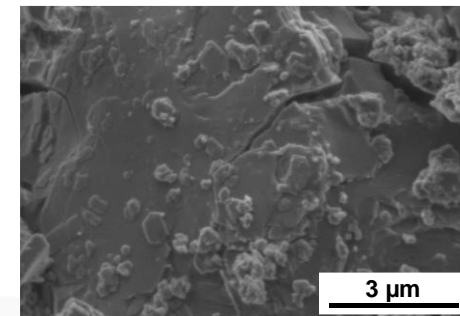
- Brucker D8 apparatus (angular range: 5 to 60 °)



X-Ray pattern of raw metakaolin M3

Scanning electronic microscopy

- JEOL IT-300 (carbon coating of the samples)

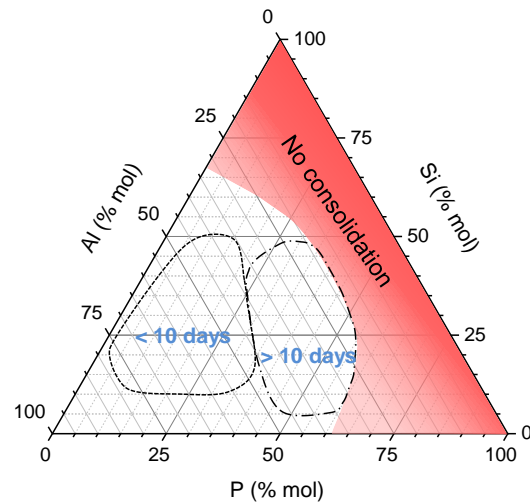


Acid based-geopolymer formed with M3

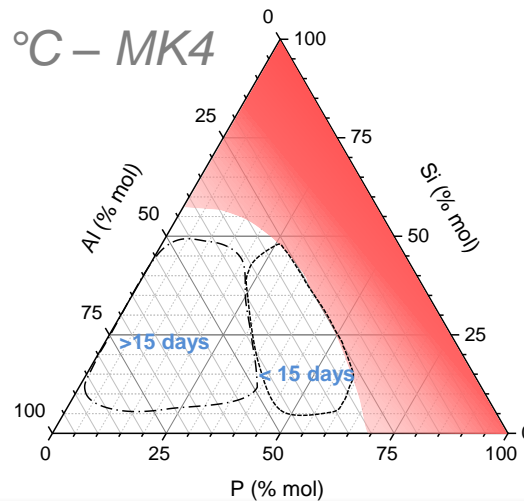
Impact of the temperature and the metakaolin

Time of consolidation

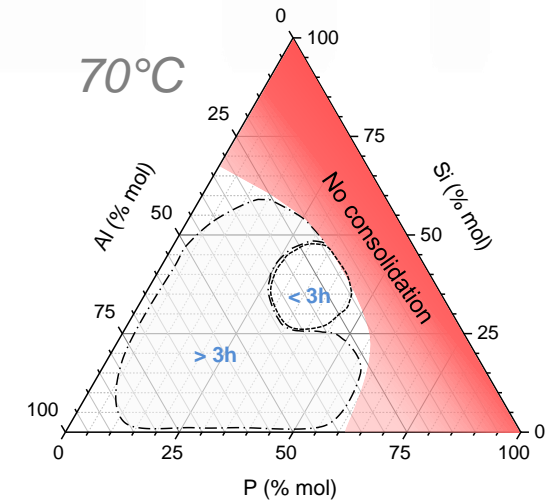
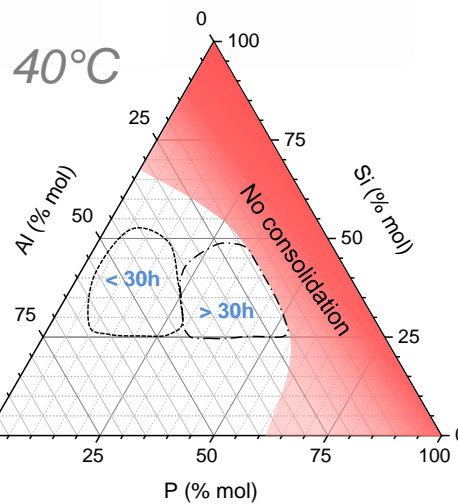
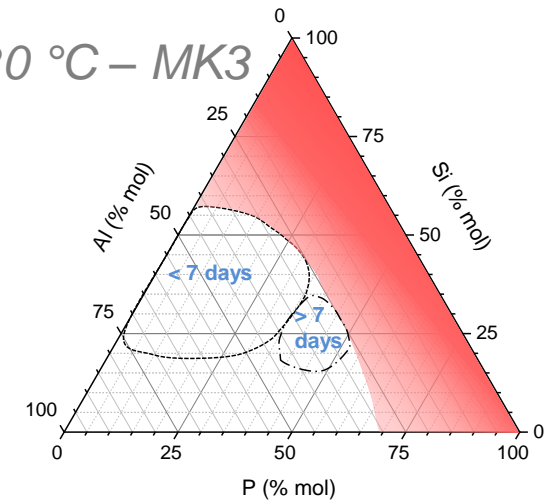
20 °C - MK1



20 °C - MK4



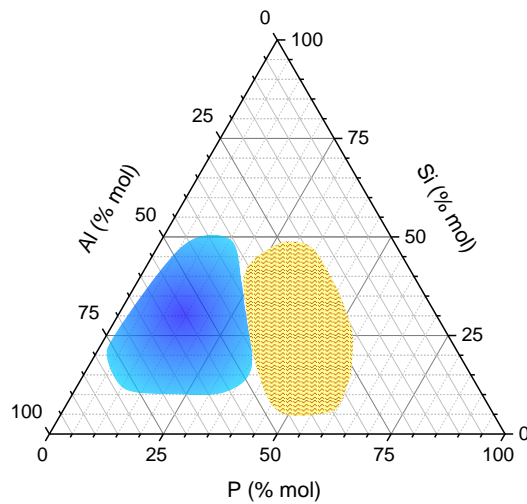
20 °C - MK3



⇒ Several zones controlled by temperature and metakaolin reactivity

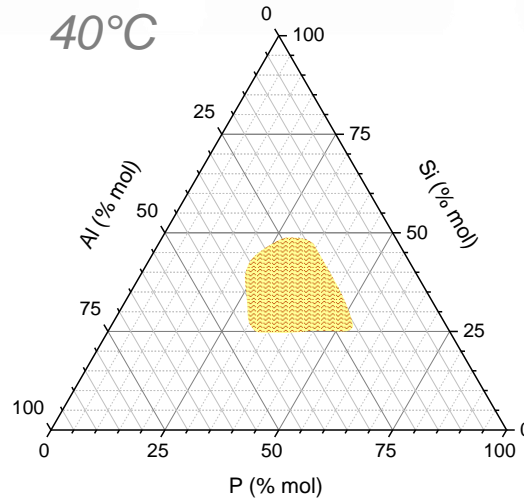
Impact of the temperature and the metakaolin

20 °C - MK1

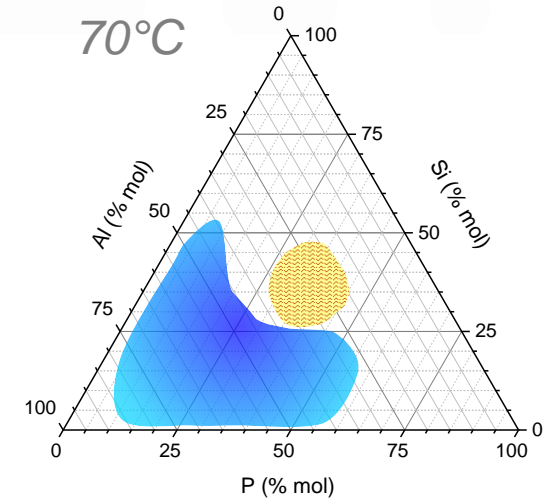


Water resistant
Fire resistant

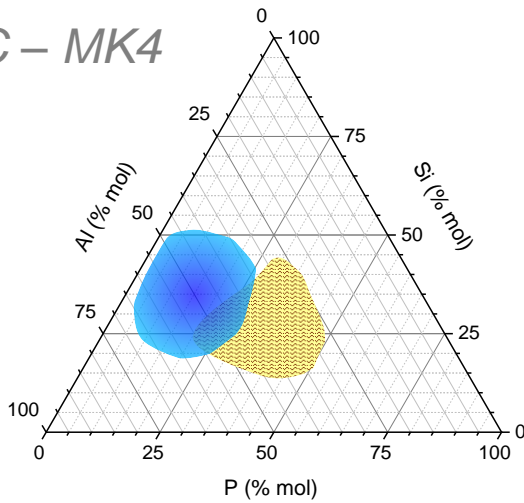
40 °C



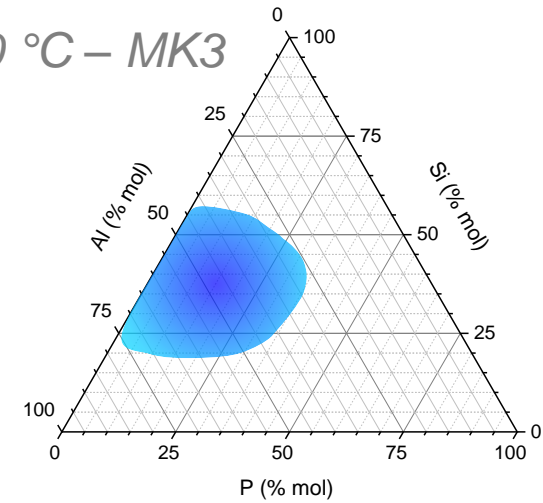
70 °C



20 °C - MK4



20 °C - MK3

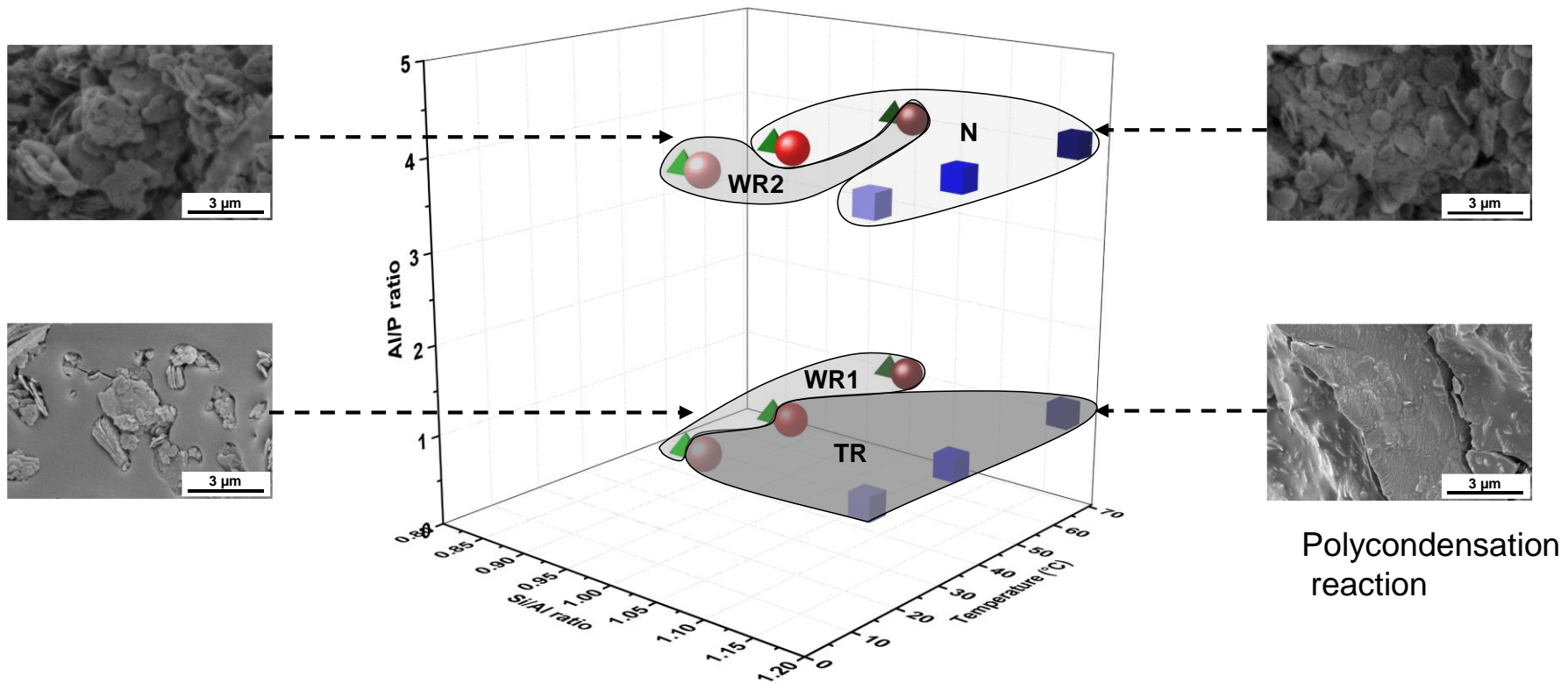


⇒ Working properties dependant on T and MK

Three family

Depending on composition

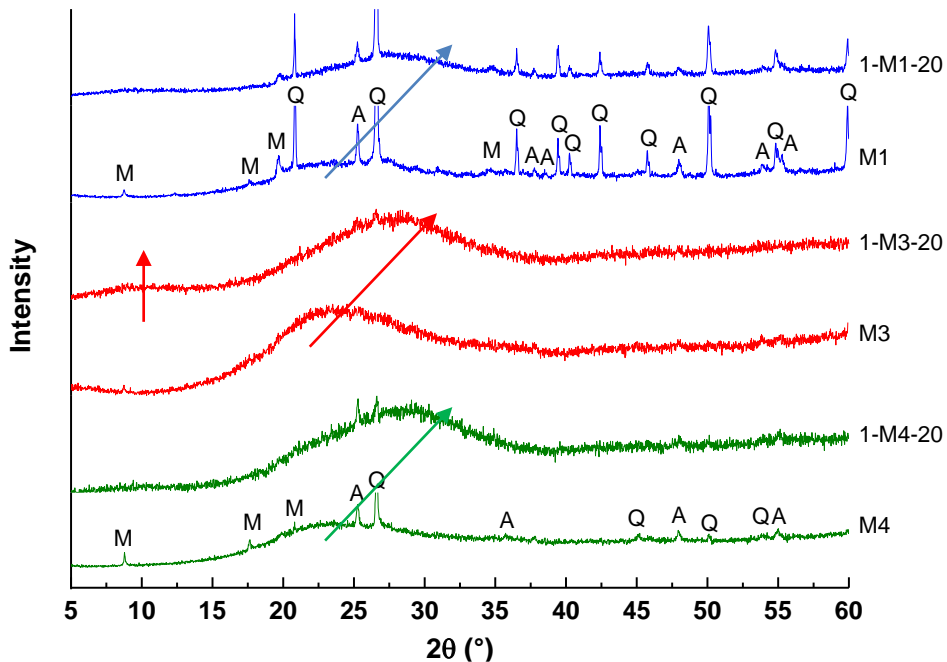
TR thermal resistant, WR water resistant, N none



⇒ How to explain the final properties?

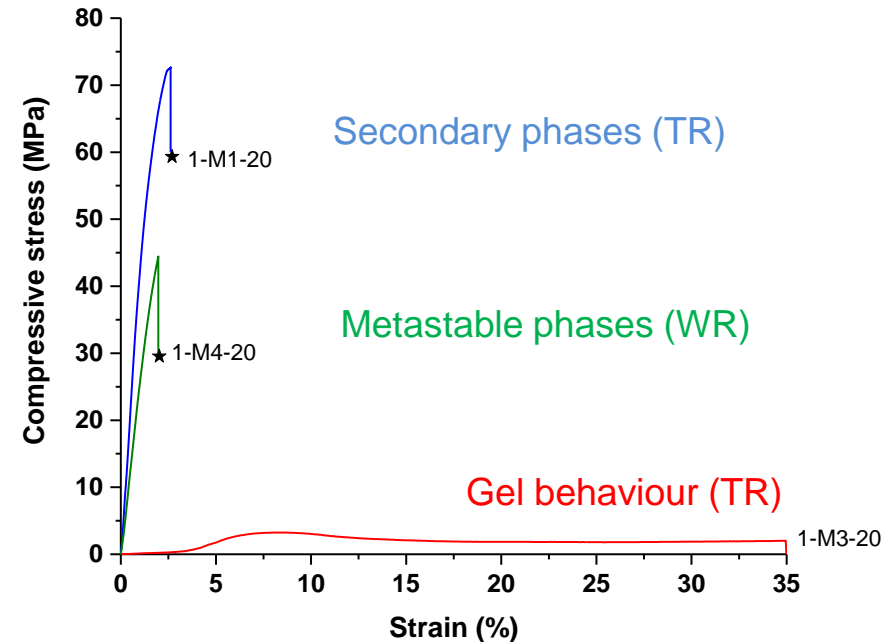
Metakaolin influence

X-ray data



- Amorphous state Al-O-P-Si?
- Another network: silicate species

Compressive strength measurements

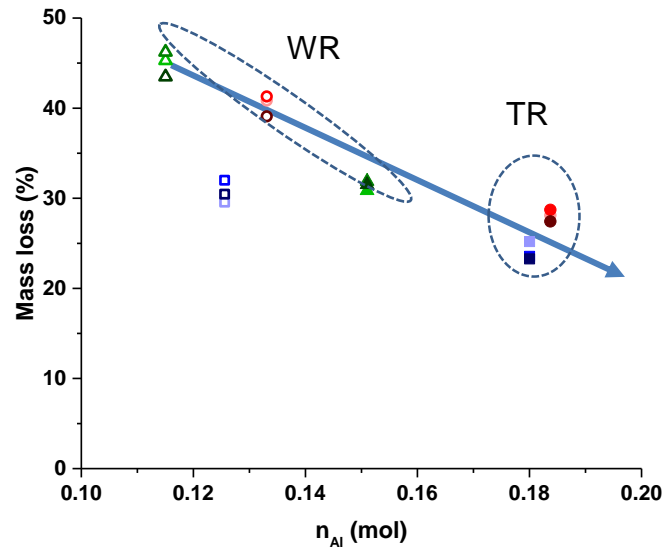


- Metakaolin reactivity

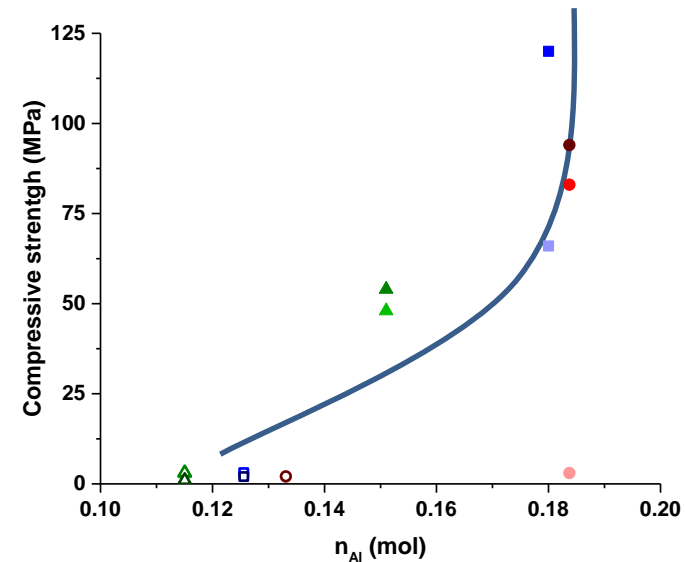
⇒ Dissolution of Al species governs the final properties

Metakaolin influence

Thermal analysis



Compressive strength



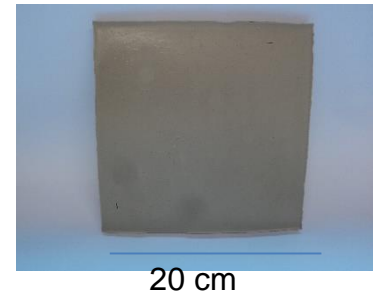
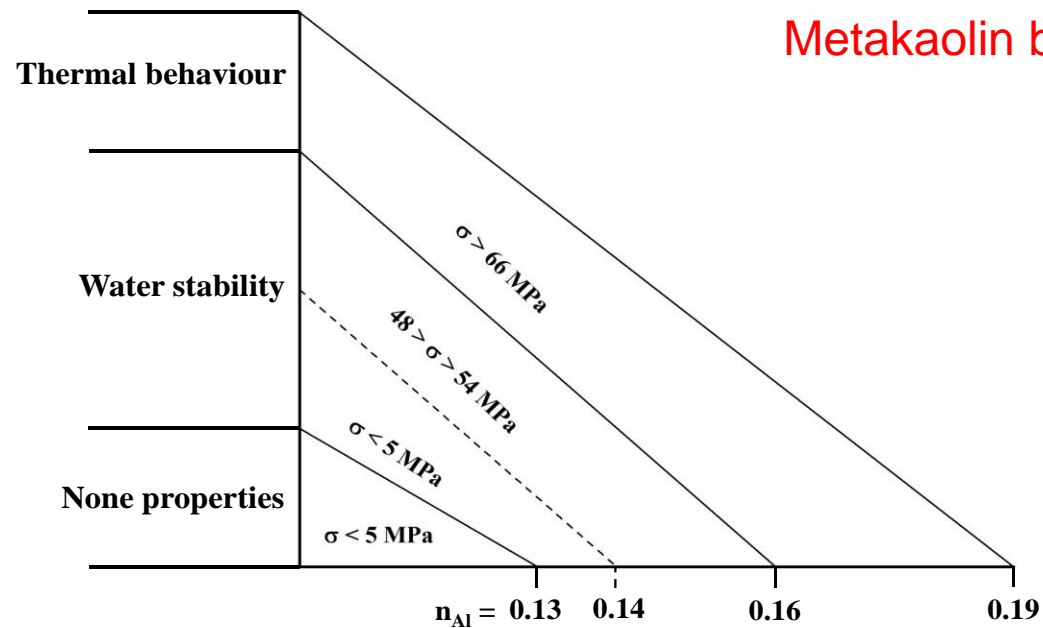
- $n_{Al} < 0.16$ WR and $n_{Al} > 0.16$ TR

⇒ Polycondensation reactions govern

Conclusion

Summary

- Various compositions are tested.



Outlook

- Understanding the formation of each compound

Thanks for
your attention.

SAVE THE DATE!
NOVEMBER
30TH 2018

III EUROPEAN
GEOPOLYMER NETWORK

ISTEC-CNR
FAENZA
ITALY

National Research Council of Italy
istec Institute of Science and Technology for Ceramics

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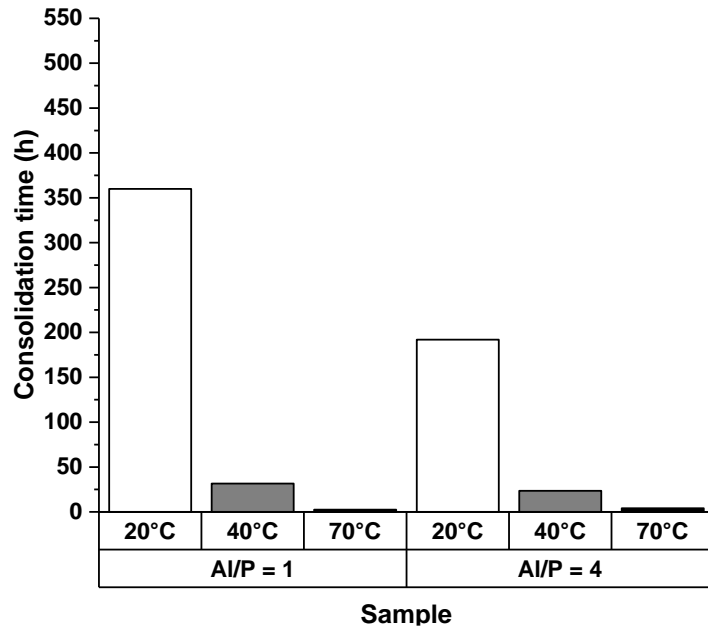
EDILTECO
group

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irCer

institut de recherche
sur les céramiques

Avec M1



Pour A/P = 1

