2025 GEOPOLYMERCAMP

Nano-Molecular Geopolymer Chemistry

Joseph Davidovits

"Advancing new Materials yet to be Discovered."

Nano-Molecular Geopolymer Chemistry, Advancing new Materials yet to be Discovered.

1) Polymeric character of geopolymers.
   The Concept of Geopolymer Micelles.
2) The tiny nanoparticles.

1) Polymeric character of geopolymers. The Concept of Geopolymer Micelles

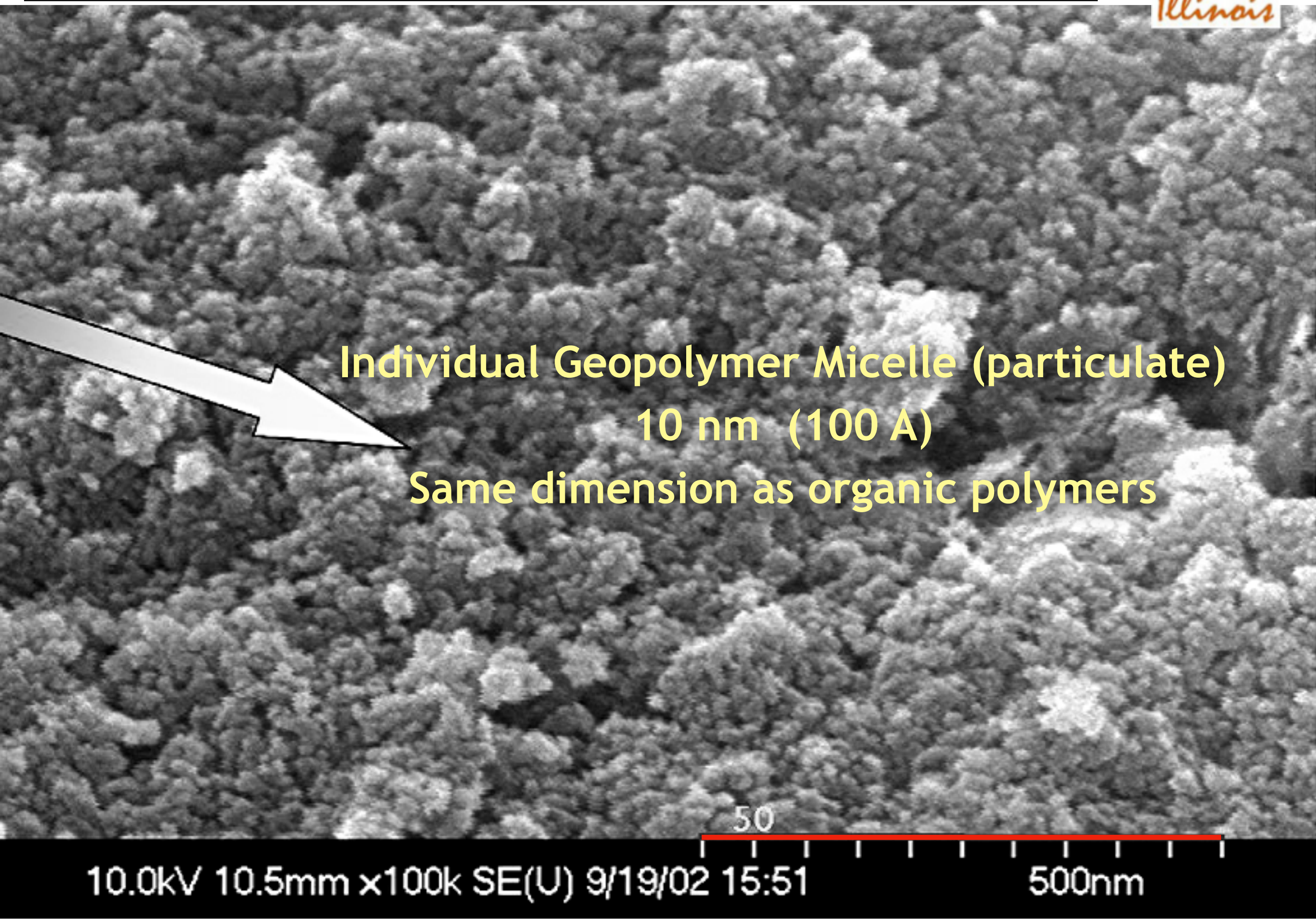
"… Joseph Davidovits introduced the term "*geopolymer micelle*" to emphasize the polymeric character of these materials and to describe the fundamental building blocks of the geopolymer structure at the nanoscale.

According to this concept, geopolymerization involves the formation of elementary, discrete nano-sized particles, typically in the range of 10-20 nm.

These nanoparticles are formed inherently during the chemical reaction sequence. The formation mechanism is linked to the polycondensation of reactive oligomers that arise from the initial dissolution of the aluminosilicate precursor…"

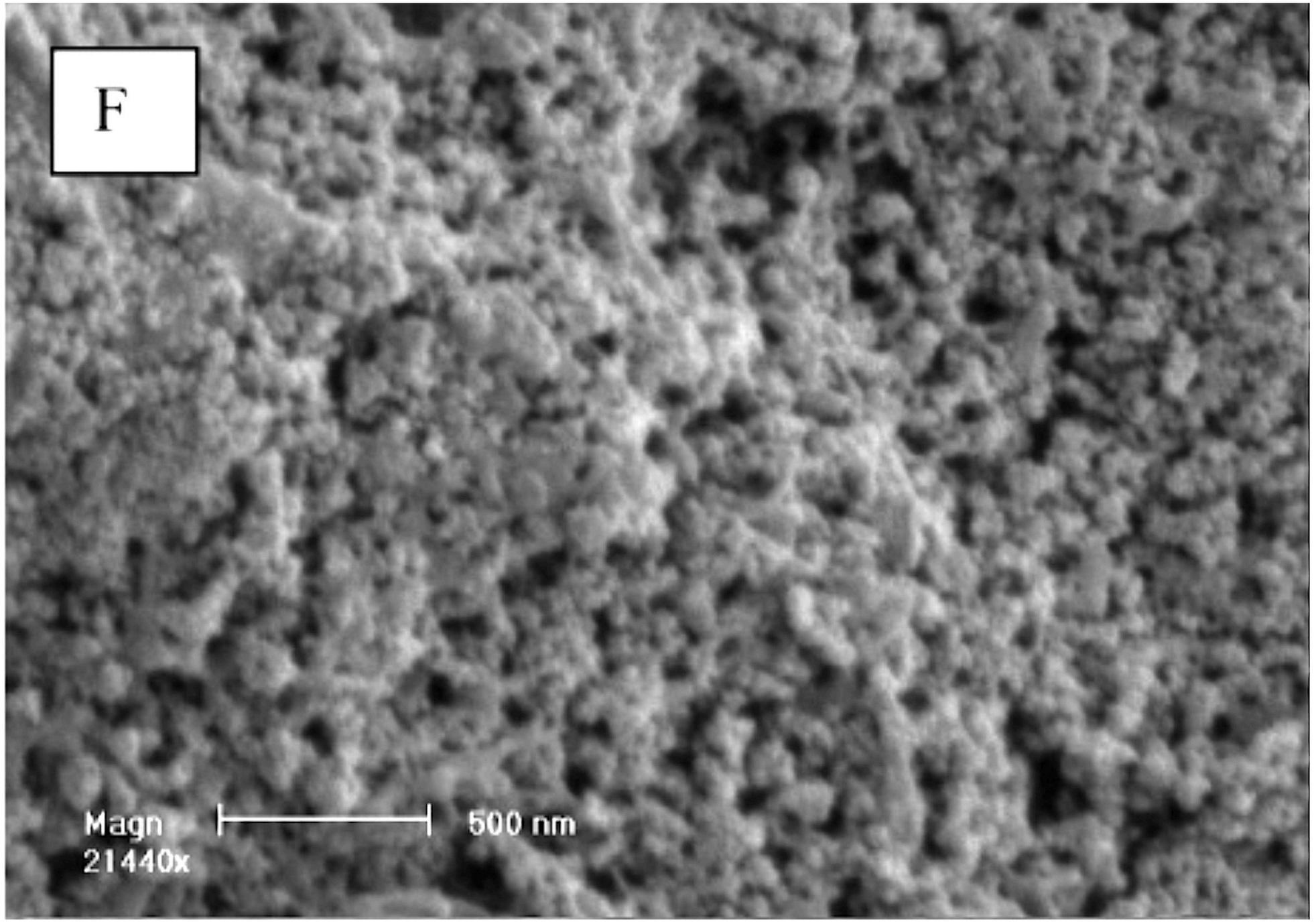
2003, Prof. Kriven's team *University of Illinois, USA*

MSE at Illinois



2006: J. van Deventer's team at University of Melbourne, Australia

2006
SEM
Fly-ash based
K-geopolymer
matrix



Effect of Curing Temperature and Silicate Concentration on Fly-Ash-Based Geopolymerization, Sindhunata, J. S. J. van Deventer,* G. C. Lukey, and H. Xu, *Ind. Eng. Chem. Res.* **2006**, 45, 3559-3568.

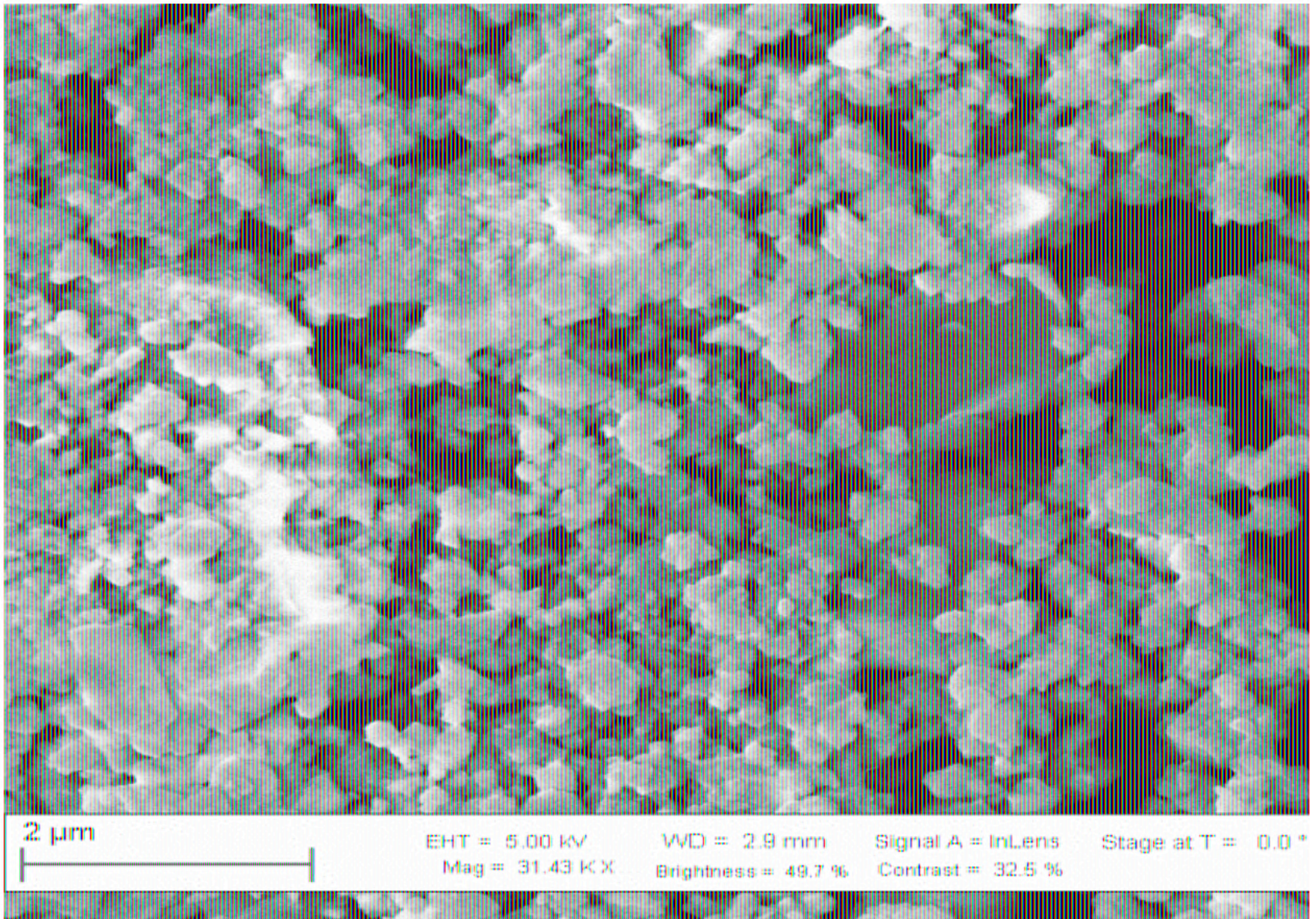
ECCM15 - 15TH EUROPEAN CONF. ON COMPOSITE MATERIALS, Venice, Italy, 24-28 June 2012

Dražan Jozić, Siniša Zorica, Darko Tibljaš, Sigrid Bernstorff
Univ. of Split, Zagreb, and Sincrotone Trieste, Italy

Insitu SAXS/WAXS Study of the Developing Process of Geopolymer Structures

2012
Na-based GP

SEM

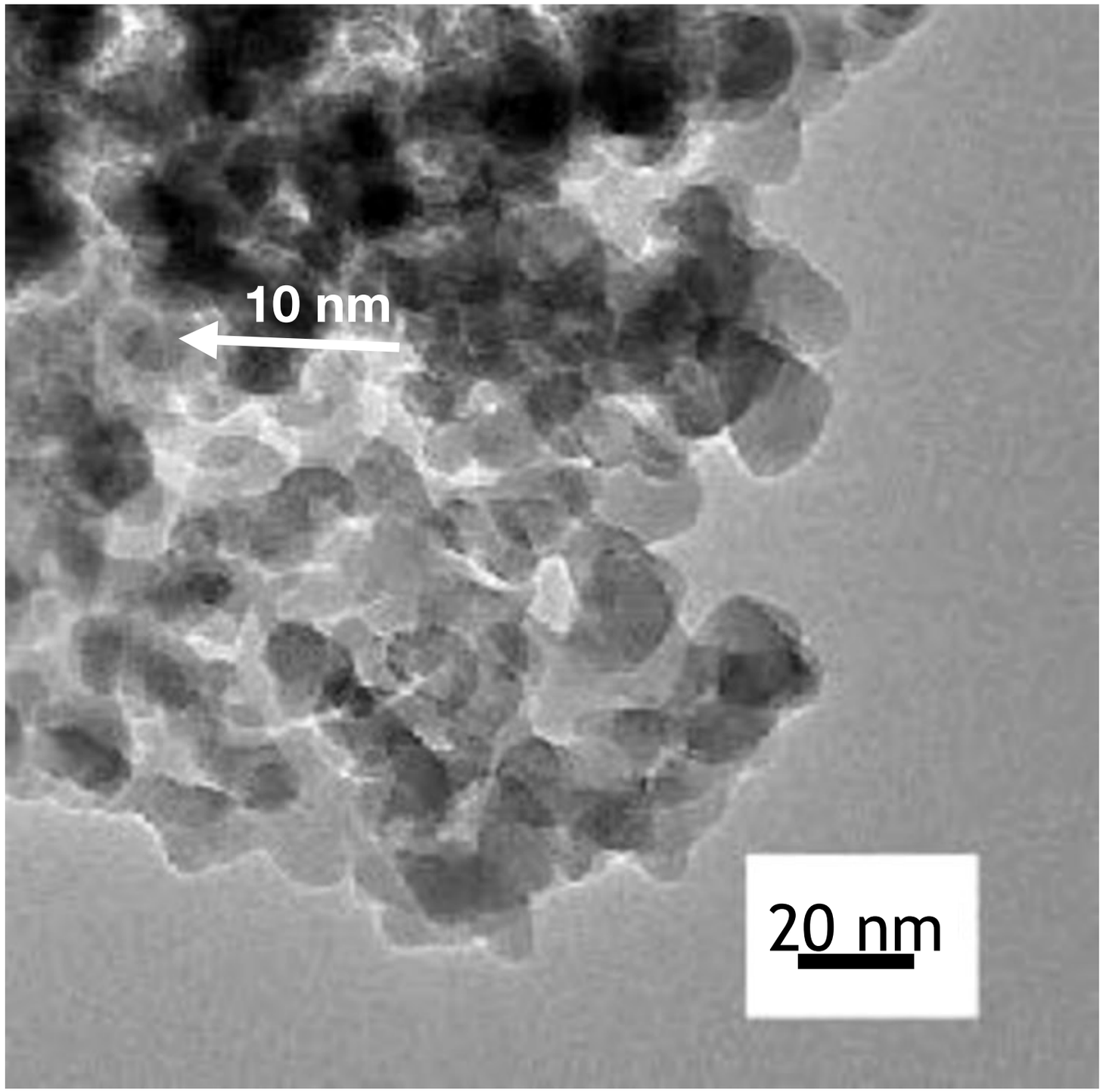


2012 Dong-Kyun (Don) Seo's team School of Molecular Sciences, Arizona State University, Tempe, USA

2012

K-based GP

TEM



presented at the Geopolymer Camp 2018 under the title: ***Nanoaggregates Synthesis from Low-Temperature Geopolymerization Process***

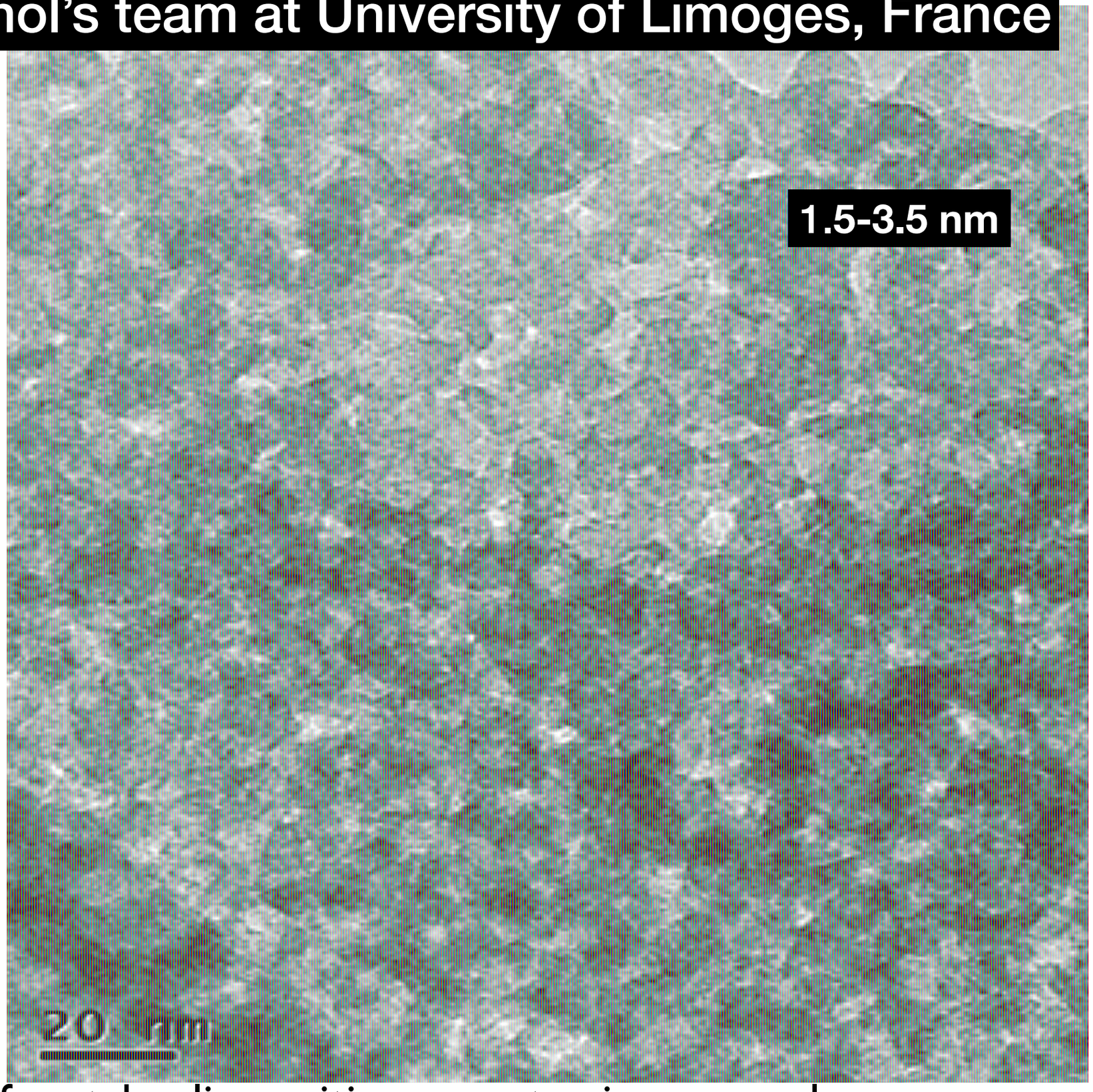
2) The tiny nanoparticles.

2013: S. Rossignol's team at University of Limoges, France

2013

K-based GP

TEM



A. Autef *et al.*, Influence of metakaolin purities on potassium geopolymer formulation: The existence of several networks, *J. Colloid and Interface Sci.*, **408**, 43-53 (2013)

2023: Geopolymer Institute

meta-kaolinite

Geopolymer-micelles

100 nm

SU5000 20.0kV x50.0k SE(L) C90F N 22/07/2023 1.00µm

2023: Geopolymer Institute

GEOPOLY INST

Geopolymer-micelles

10-20 nm

1.5-3.5 nm

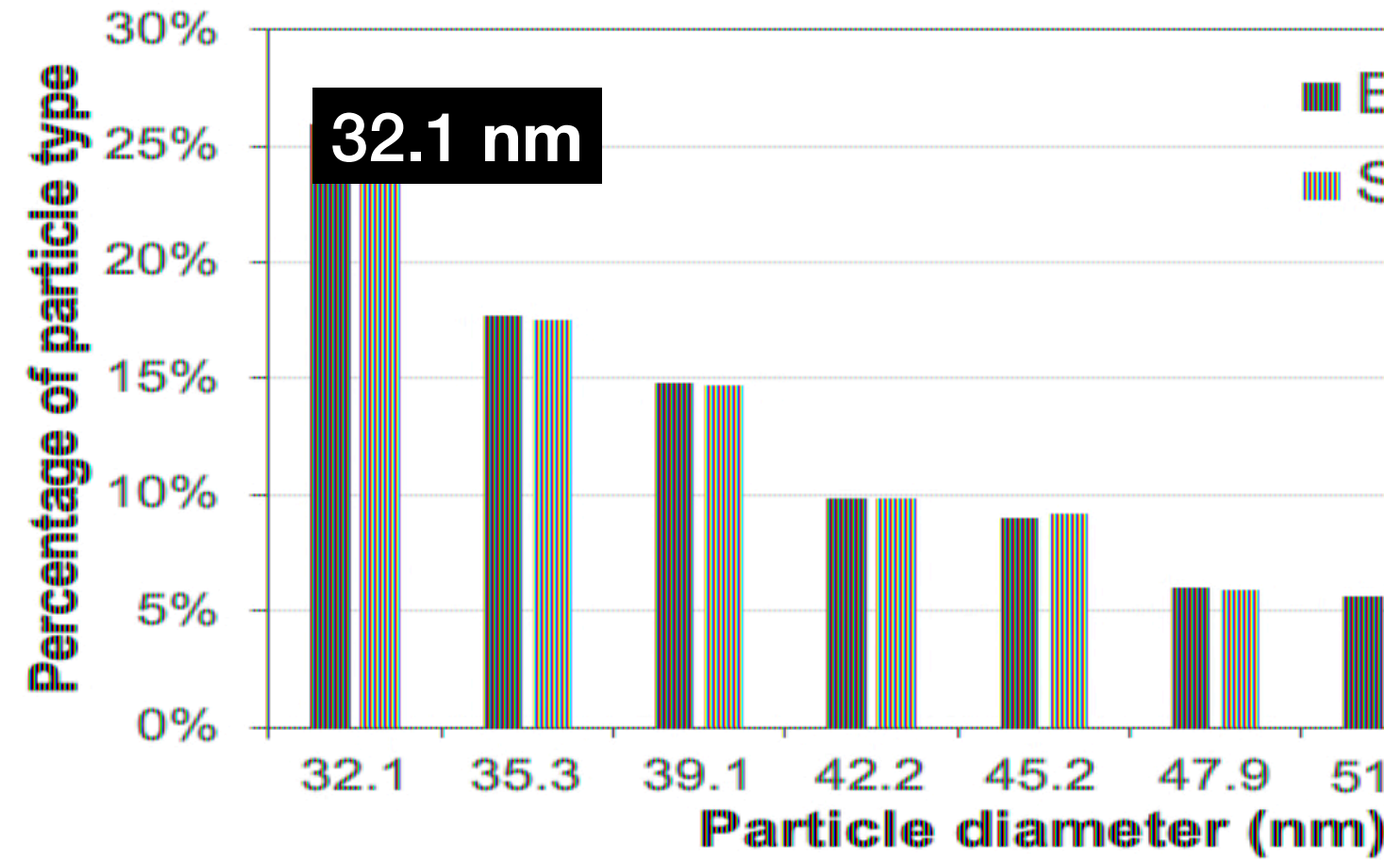
100 nm

CERAMA

SU5000 20.0kV x50.0k SE(L) C90F 20 22/07/2023 1.00µm

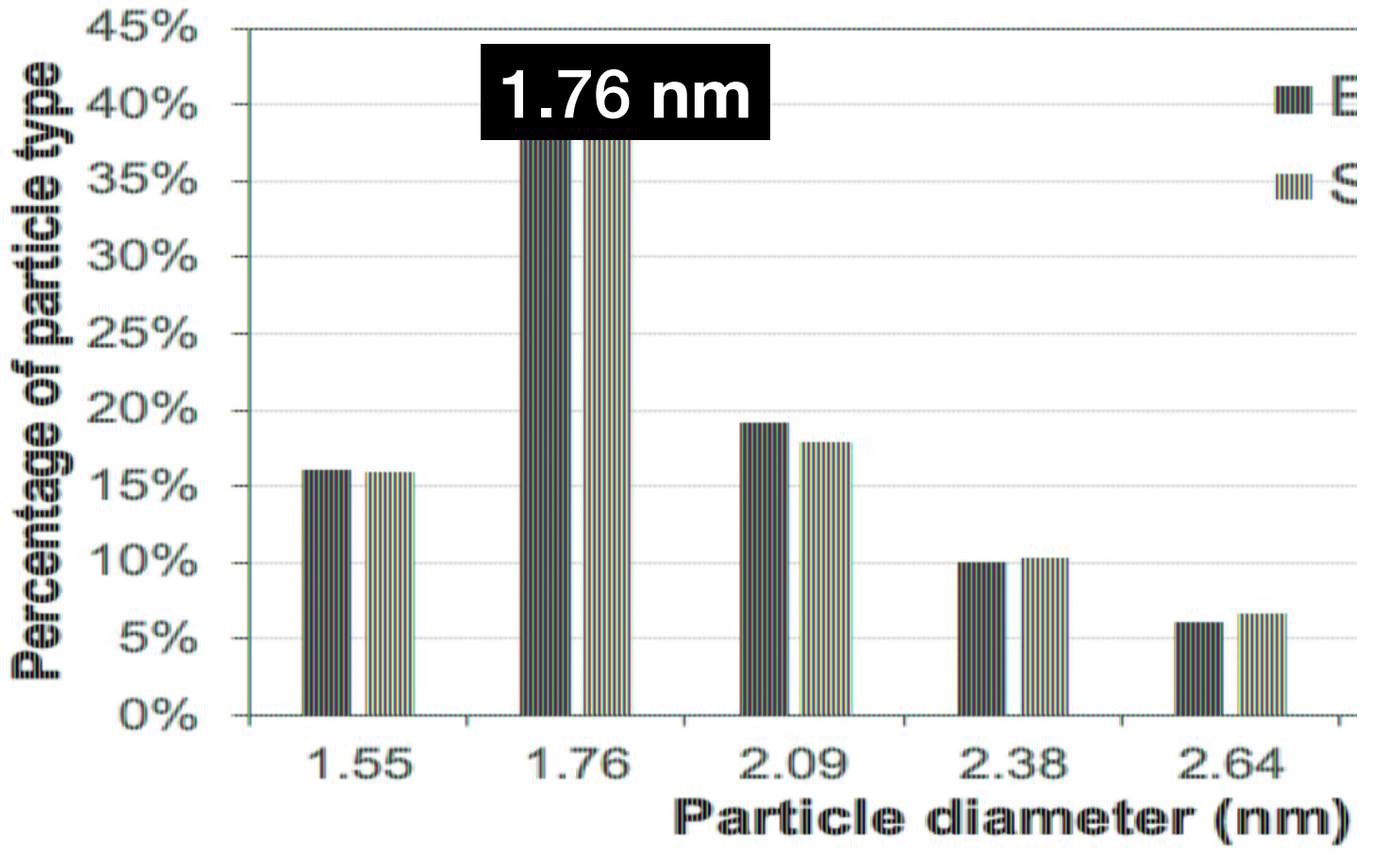
2025: A-T. Prof. Akono's team at North Carolina University USA

Na-based GP-nanoparticles



Adapted from E. Masoero *et al.*, Nanoparticulates of Sodium and Potassium Geopolymer Gels/ Experiments, ***Molecular Dyn 2025***

K-based GP-nanoparticles



"….These oligomers act as the monomeric or precursor units that polymerize and cross-link, not into a perfectly continuous gel initially, but into these discrete nanoparticles .The aggregation and further bonding between these primary nanoparticles constitute the "Geopolymer micelles" and the final hardened geopolymer matrix.

Davidovits distinguishes this model, emphasizing a true polymerization process leading to a well-defined 3D polymeric network built from these nano-units, away from the simpler descriptions that might equate the geopolymer binder solely to an amorphous hydrate gel (like N-A-S-H or K-A-S-H, terms sometimes used analogously by cement scientists)…"

Colloidal
silica
30-40 nm

GP-micelle
10-20 nm

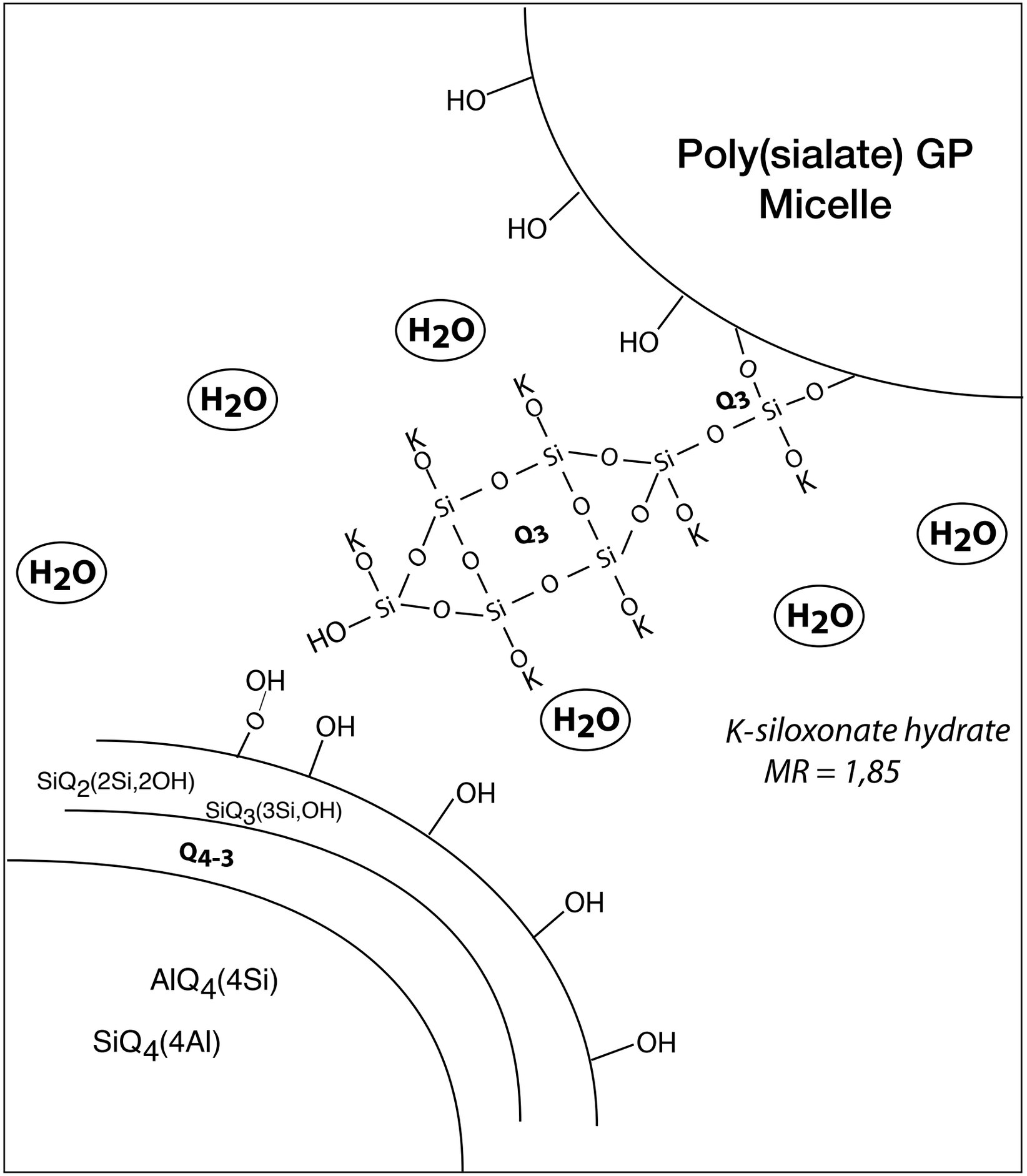
Silica Fume
200-300 nm

Fly ash
3-15 μ

Poly(sialate) Geopolymer = nano material
not unknown « Gel » or « Hydrate »

Inter-micellar structure after geopolymerisation.

OH on GP Micelle surface,
silicate molecules,
water



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