National Technical University of Athens
School of Mining and Metallurgical Engineering
Laboratory of Metallurgy

Research Group on Geopolymerization Engineering

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Group Leader
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PhD Candidate
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PhD Candidate

4-6 of July 2011, SAINT QUENTIN, FRANCE

OBJECTIVES

- **Understanding of the fundamentals of the Geopolymerization Technology**

  A (1) basic research project funded by NTUA has already been performed

- **Testing the geopolymeric behaviour of several by-products from the Mining and Metallurgy sector**

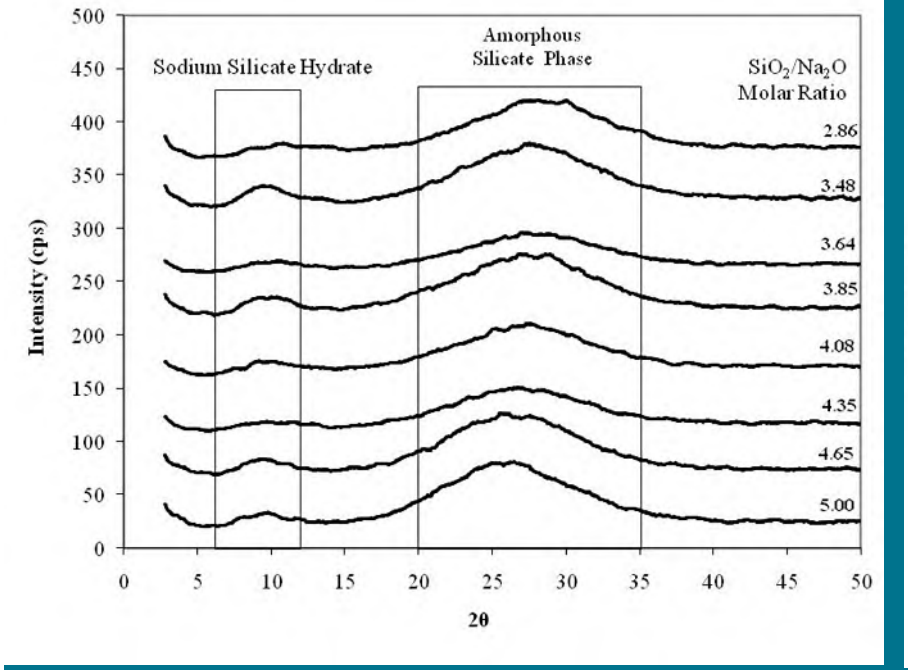
  Four (4) projects funded by Greek Industries have already been performed

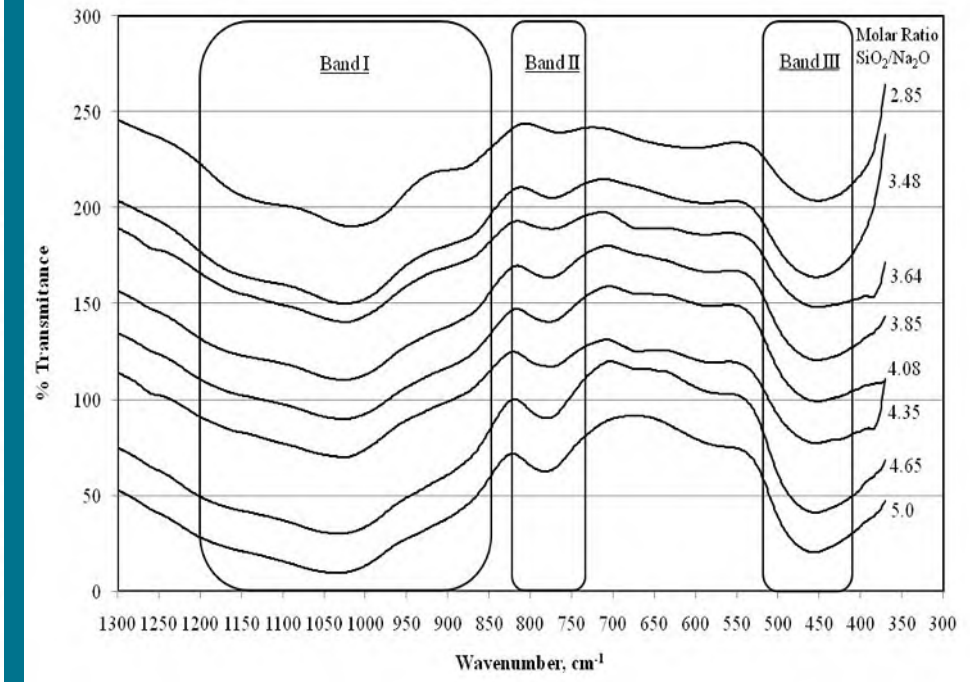
- **Developing thermal insulation and fire resistant materials**

  Three (3) projects funded by EC and Greek authorities as well as a German Industry are currently in progress

BASIC RESEARCH

We performed gelation experiments in pure sodium silicate as well as sodium aluminosilicate solutions in order to study the gels' structure and correlate the structure with the gel properties





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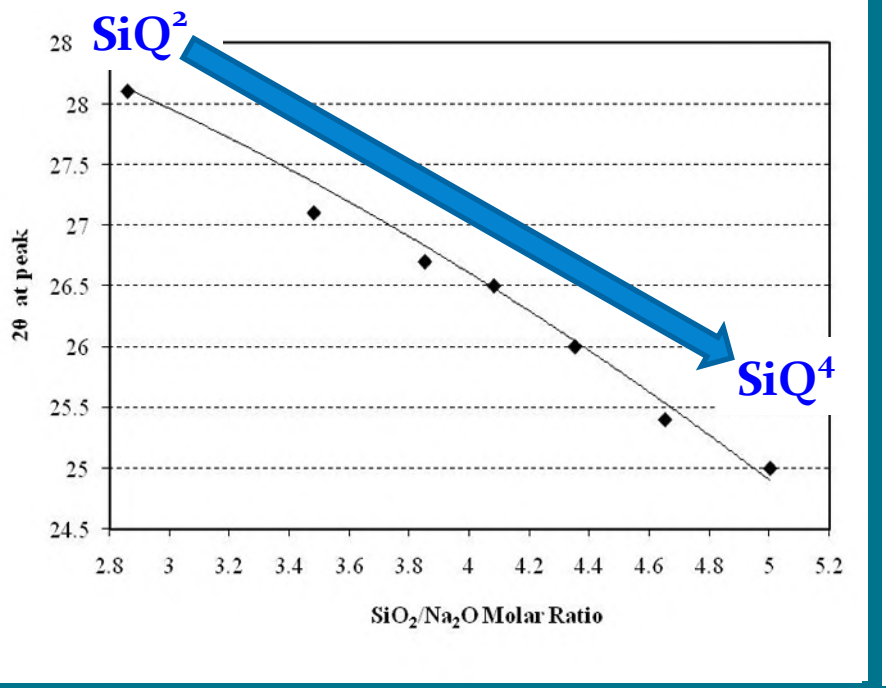

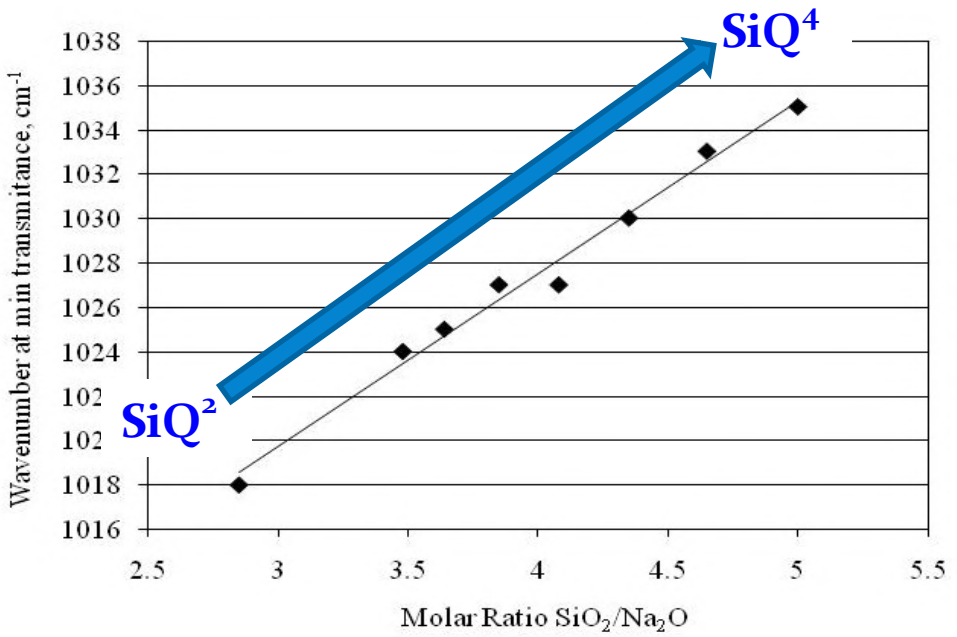

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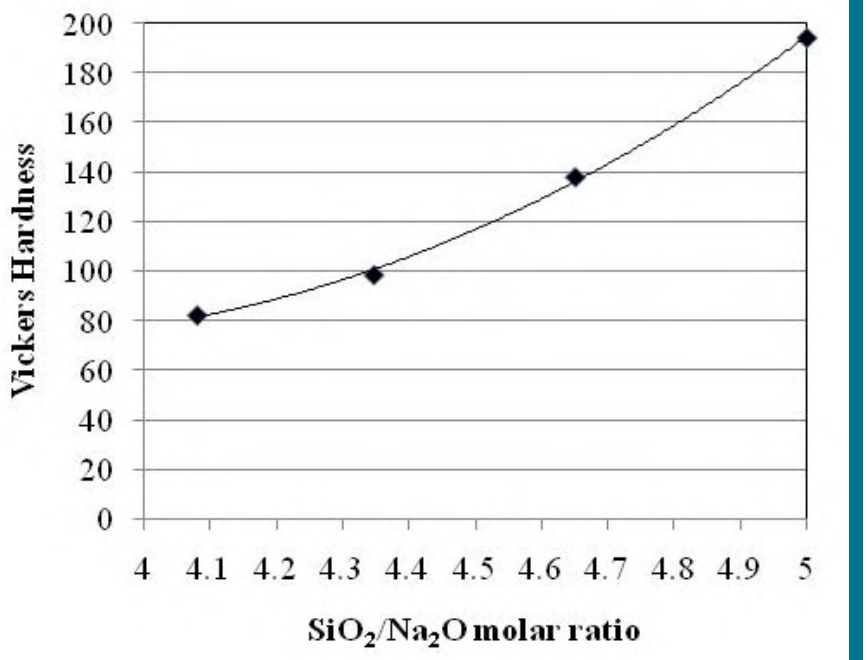

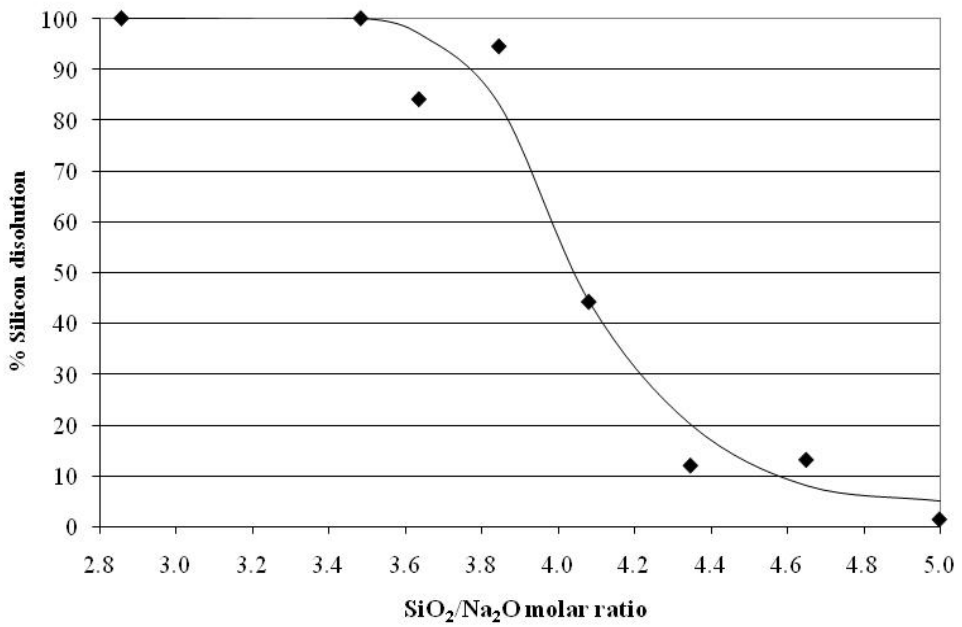

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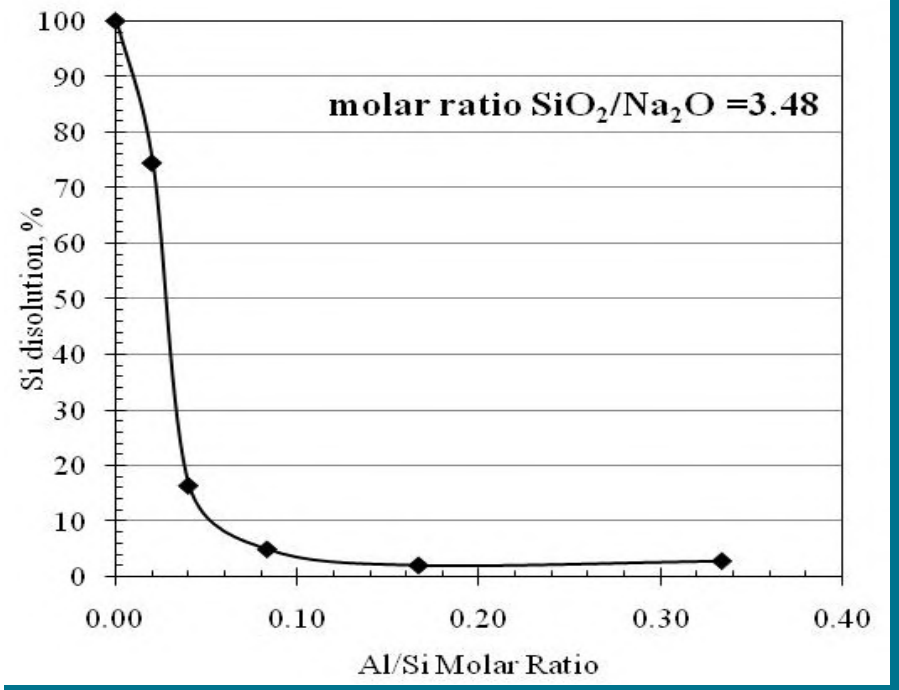

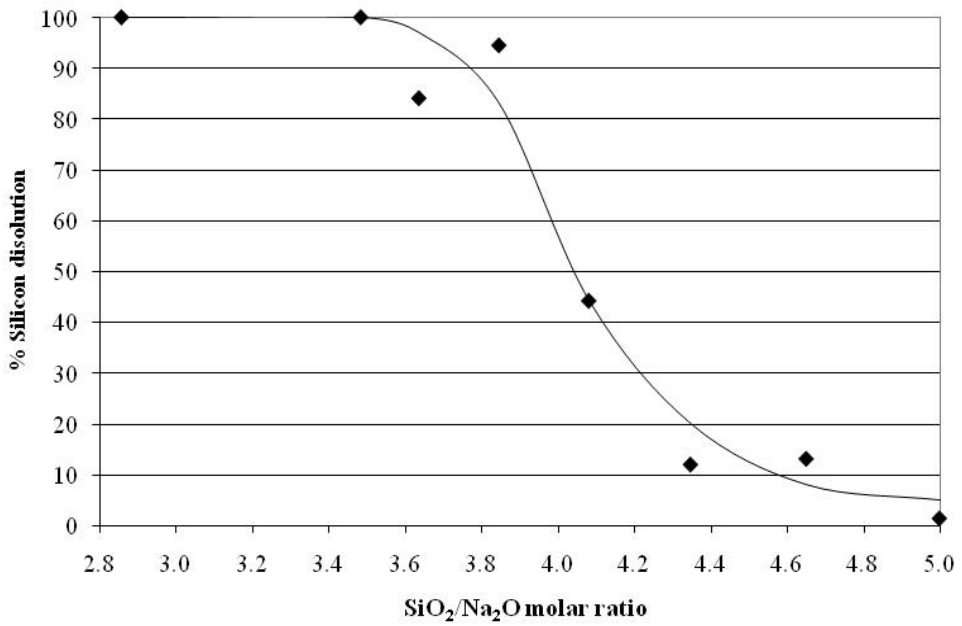

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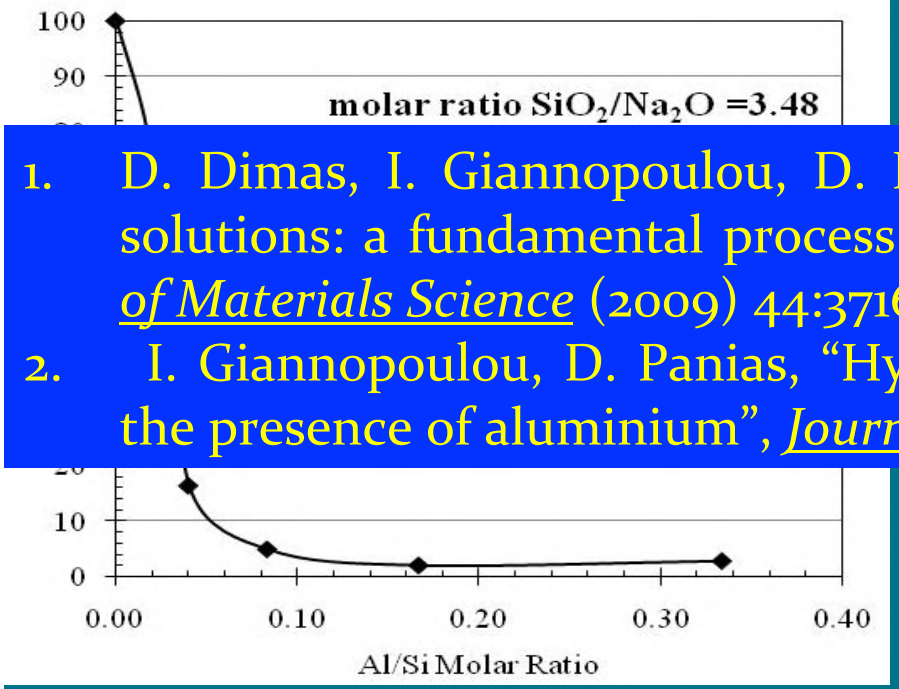

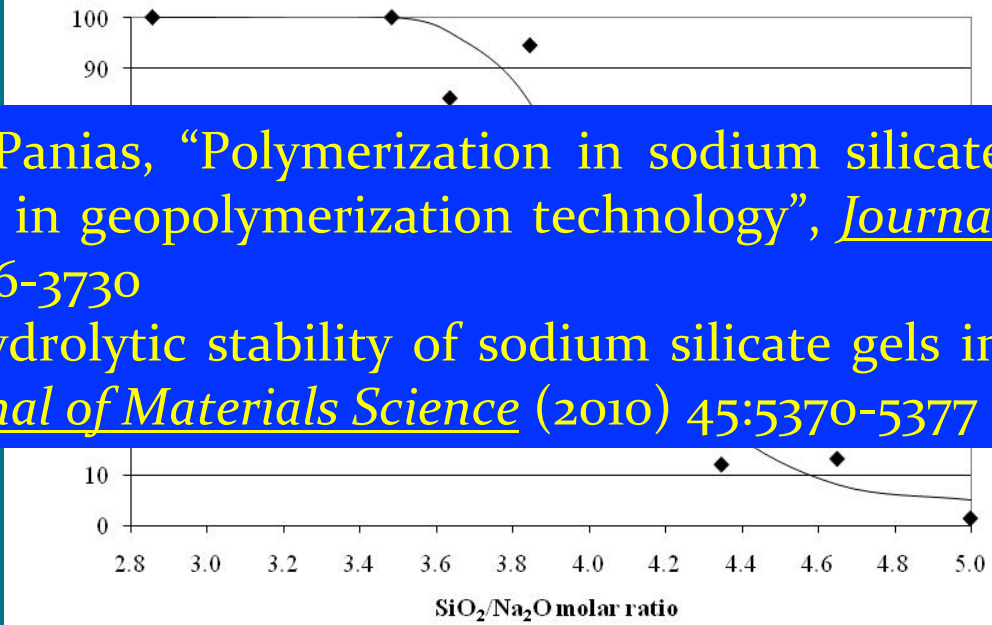

1. D. Dimas, I. Giannopoulou, D. Panias, "Polymerization in sodium silicate solutions: a fundamental process in geopolymerization technology", *Journal of Materials Science* (2009) 44:3716-3730
2. I. Giannopoulou, D. Panias, "Hydrolytic stability of sodium silicate gels in the presence of aluminium", *Journal of Materials Science* (2010) 45:5370-5377

Geopolymerization of several industrial by-products

We tested a number of aluninosilicate in nature industrial by-products locally available in Greece

- **Fired coal fly ashes**

D. Panias, I. Giannopoulou, T. Perraki, "Mechanical properties of fly ash-based geopolymers", *Colloids and Surfaces A: Physicochemical & Engineering Aspects* 301 (2007) 246-254

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I. Maragos, I. Giannopoulou, D. Panias, "Synthesis of ferronickel slag-based geopolymers", *Minerals Engineering* 22 (2009) 196-203

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1. I. Giannopoulou, D. Panias, "The geopolymerization technology for the utilization of mining and metallurgical wastes", *Proceedings of the European Metallurgical Conference EMC 2007* Dusseldorf, Germany (2007) 625-640
2. I. Giannopoulou, N. Katsiotis, D. Panias, "Mechanical properties and thermal behaviour of geopolymeric materials synthesized from solid wastes of industrial minerals exploitation", *Proceedings of the 3rd Pan-Hellenic conference on metallic materials* Patra, Greece (2007) 423-428
3. I. Giannopoulou, D. Dimas, I. Maragos, D. Panias, "Utilization of metallurgical wastes/by products for development of inorganic polymeric construction materials", *Global NEST Journal* 11(2), 2009 127-136

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- **Overburdens from bentonite exploitation – Ultrafine perlite – Metakaolin – Flotation tailings from copper mines**

Among them ultrafine perlite and Feni Slag were selected for development of high added value inorganic polymeric materials

Thermal Insulation Materials based on Perlite

Two types of materials are under development

1. **Foamed geopolymeric materials based on ultrafine non-expanded perlite**
2. **Bound expanded perlite with geopolymeric pastes**

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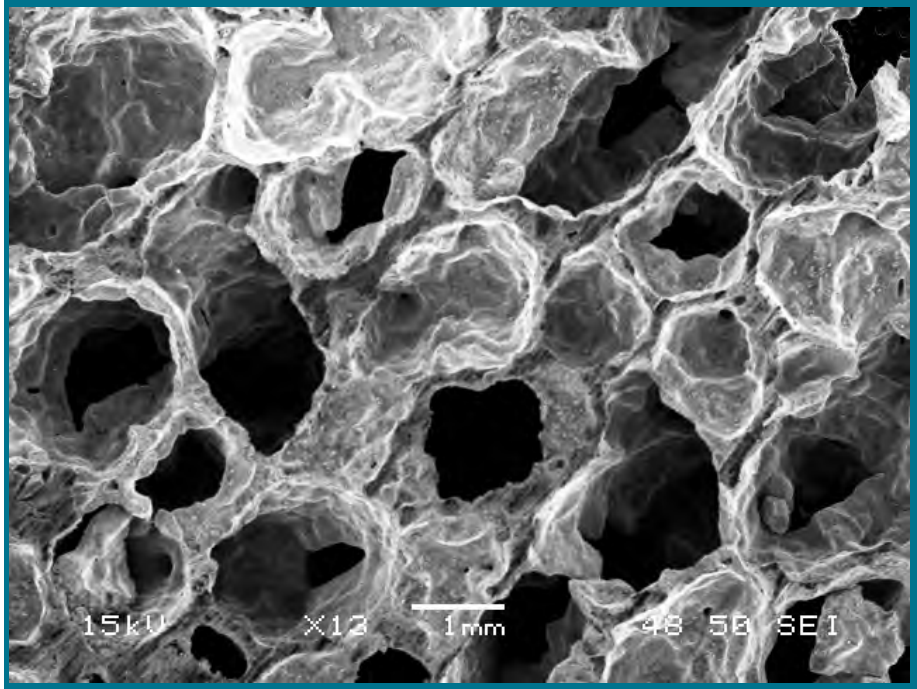

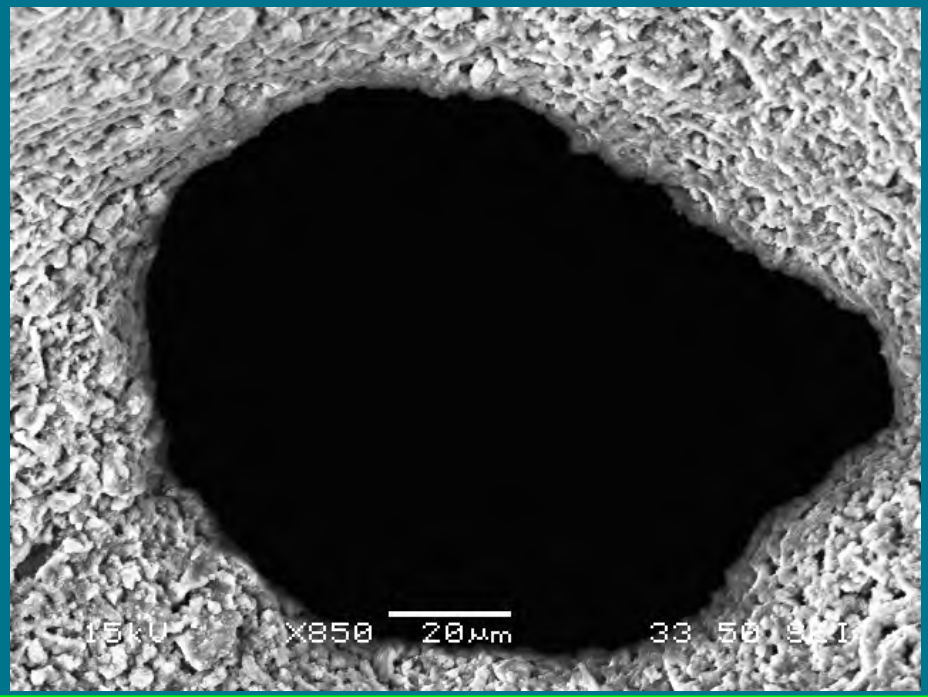

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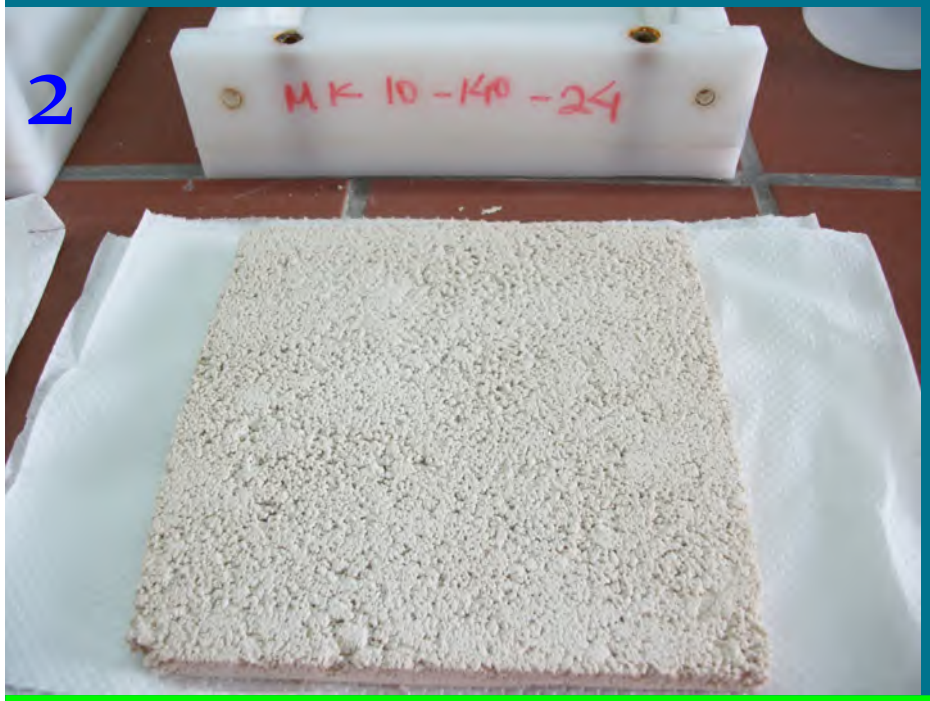

Thermal Insulation Materials based on Perlite

Two type
1. Foam
   expar
2. Boun

Material	Glass wool	Mineral wool	Extruded Polystyrene XPS	Expanded Polystyrene EPS	Foamy perlite Geopolymer	Bound Expanded Perlite
Apparent Density kg/ m^3	13 – 100	30 – 180	20 – 80	18 – 50	290	250 - 350
Thermal Conductivity W/m.K	0.03–0.045	0.033-0.045	0.025-0.035	0.029-0.041	0.03	0.03 -0.04
Maximum Application Temperature ^oC	500	750	75	80	700	900
Fire Class	A1 – A2	A1 – A2	B1 – B2	B1 – B2	A1	A1
Compressive Strength at 10 % deformation kPa	16	0.01 - 69	100 – 700	70 – 450	780	20 - 70

ne non-

V. Vaou, D. Panias, "Thermal insulating foamy geopolymers from perlite", *Minerals Engineering* 23 (2010) 1146-1151

Fire resistant Materials based on FeNi-Slag

We are concentrated on materials for passive fire protection of tunnels that have the ability to set:

- a flame barrier reducing the possibility of spreading of an incipient fire

- a temperature barrier preventing the failure of construction elements such as concrete, steel rebars etc

Compact geopolymeric slabs

put on the surface of a concrete slab

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Exposed to a simulated fire

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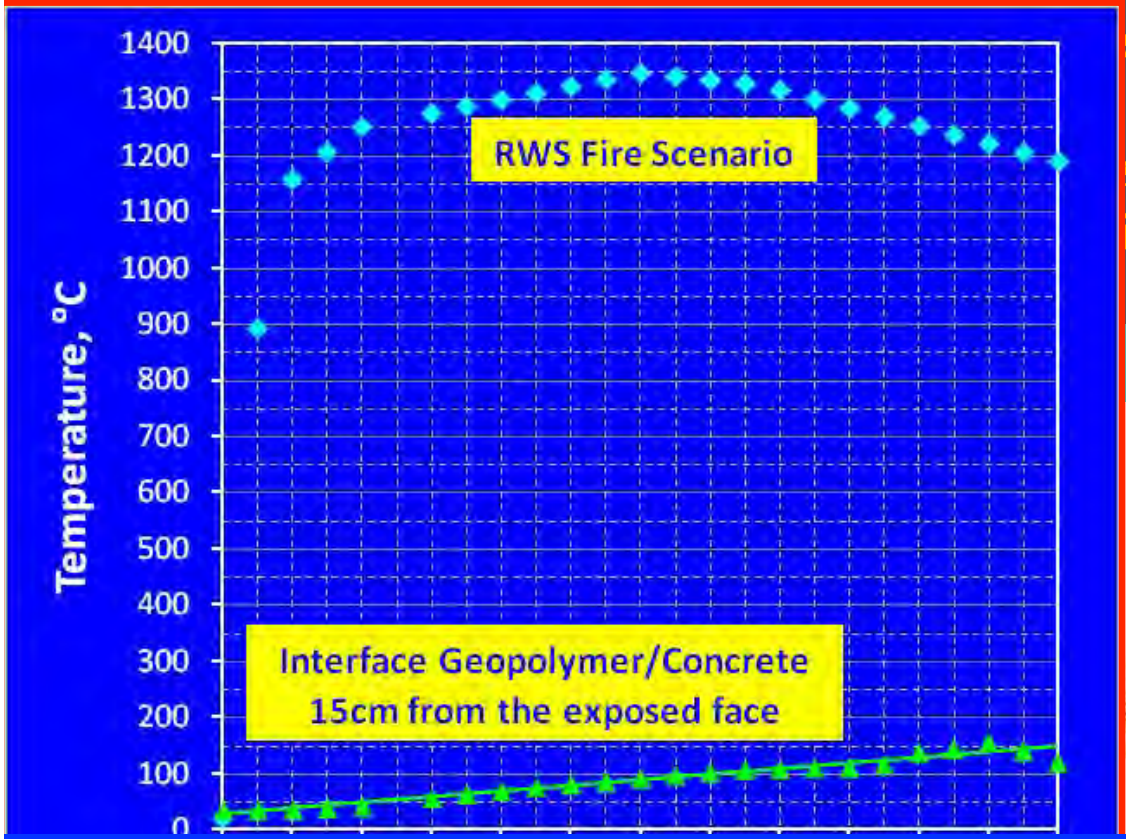

T > 300 °C severe concrete spalling phenomena

T > 550 °C severe steel rebars damages (expansion, softening and diminished structural integrity

Exposed to a simulated fire

1. I. Giannopoulou, D. Panias, "Fire resistant geopolymers synthesized from industrial wastes", *World Journal of Engineering* 5(3), 2018 130-131
2. K. Sakkas, D. Panias et al., "Inorganic polymeric materials for passive fire protection of underground constructions", *Fire & Materials*, 2011, under review

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THANK
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