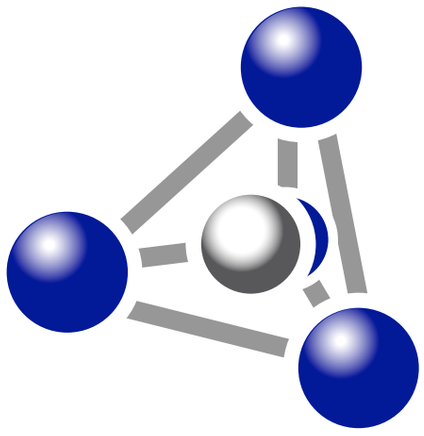


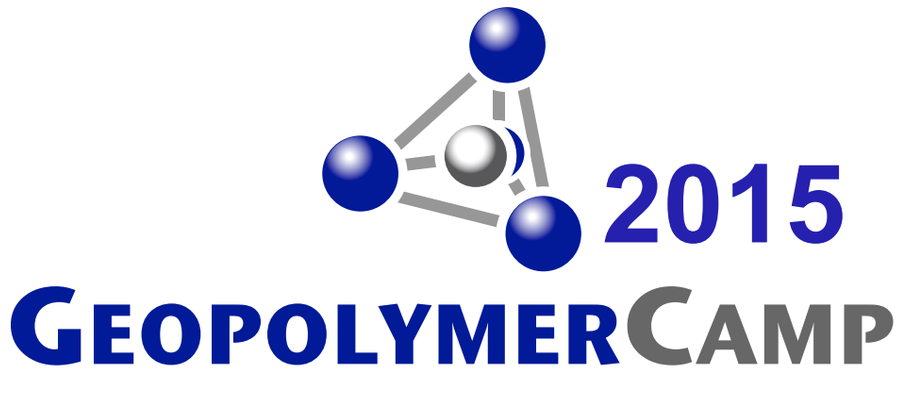
2015 GeopolymerCamp

www.iut-aisne.fr

Saint-Quentin (France)

July 6-8, 2015

State of the Geopolymer R&D 2015



Joseph Davidovits

Previous State of the Geopolymer at GP-Camps

2009: Mass Produced Geopolymer Cement

2010: State of the Geopolymer R&D 2010

2011: State of the Geopolymer R&D 2011

2012: State of the Geopolymer R&D 2012

2013: State of the Geopolymer R&D 2013

2014: State of the Geopolymer R&D 2014

Geopolymer CAMP July 6-8, 2015

Registered Participants

GEOPOLYMERCAMP

TUTORIAL WORKSHOP

State of the Geopolymer R&D 2014

1) Geopolymer science

2) Geopolymer technologies

3) Geopolymer Cements / Concretes

4) Geopolymer and archaeology

State of the Geopolymer R&D 2015

1) Geopolymer science

2) Geopolymer technologies

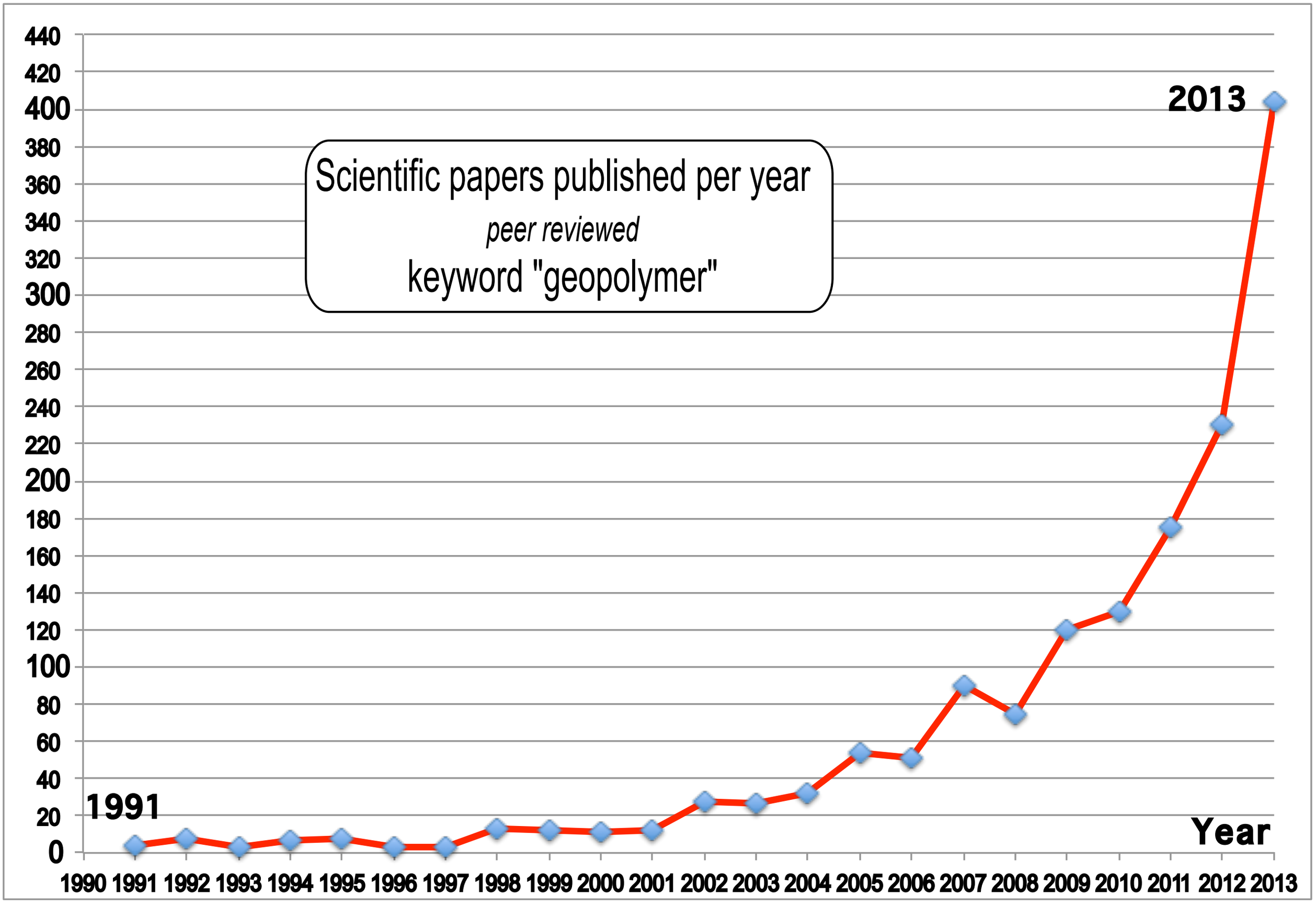
3) Geopolymer Cements / Concretes

4) Geopolymer and archaeology

Geopolymer research 1988

1st Geopolymer conference

Geopolymer research 2013


Scientific papers published per year
peer reviewed
keyword "geopolymer"
2013
1991
Year
440
420
400
380
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013

GEOPOLYMER CAMP

6th Geopolymer Camp 2014 Registration

Updated on May 25, 2014

GeopolymerCamp: July 7-8-9, 2014
Venue: IUT, Saint-Quentin; France
Organized by the Geopolymer Institute

Introducing the *Journal of Geopolymer Science*

……The **Journal of Geopolymer Science** should serve as a focal point for scientists, engineers, academicians, graduate and undergraduate students, ….. …….. The journal will be led by the founder of geopolymer science, Prof. Joseph Davidovits, assisted by world's reputed editors.

It will be aimed at providing a dedicated editorial board, zero tolerance for plagiarism and high respect for publication ethics.

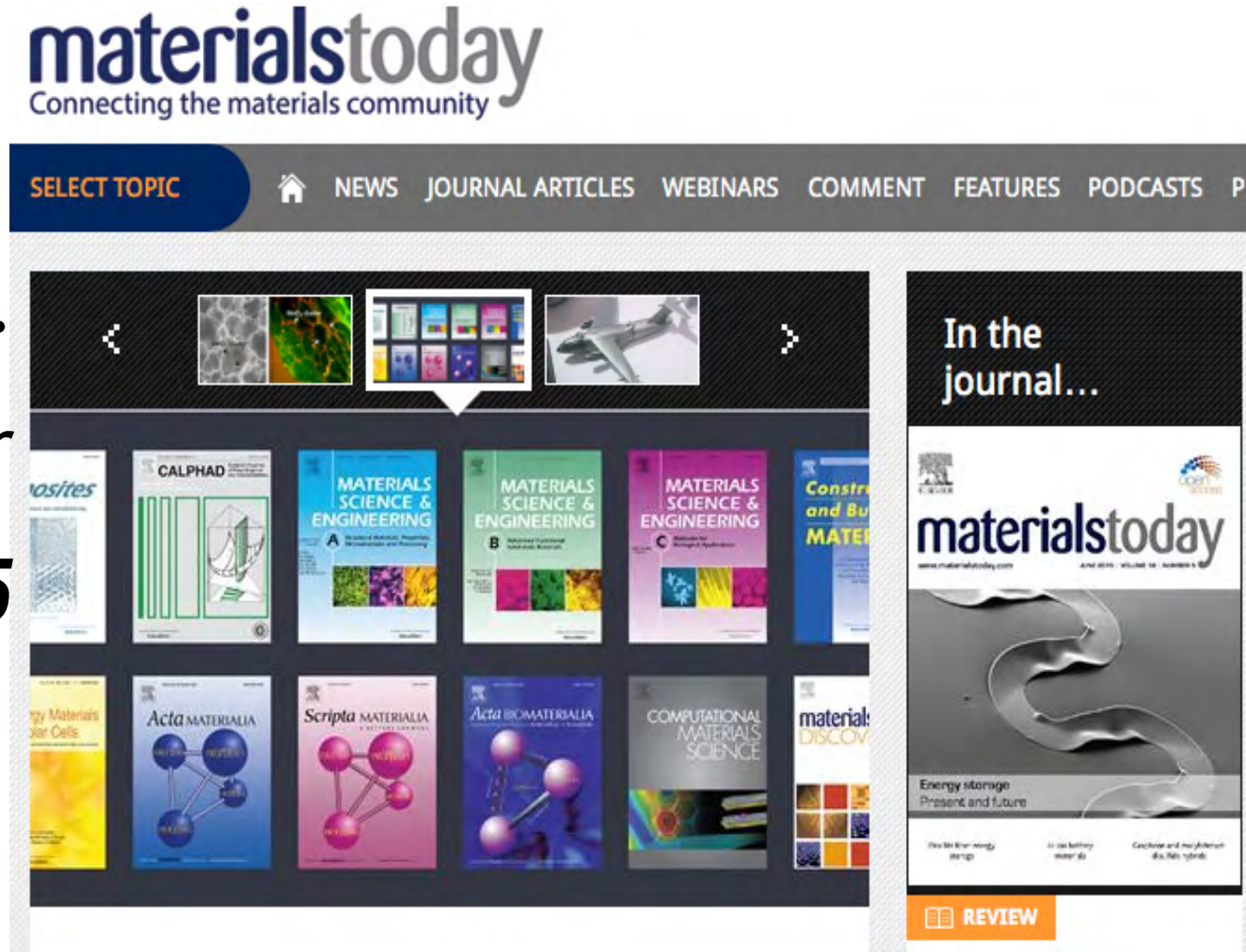
ELSEVIER – GEOPOLYMER INSTITUTE

virtual

Journal on Geopolymer Science

A collection of already published research papers, curated by us, all relating to geopolymers:

- Hosted on ***Materials Today***
- Divided into different themes.
- Free resource for the first year
- ***On line: June 2015***



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★ FEATURE

Environmental implications of Geopolymers

29 June 2015 | Joseph Davidovits

Comment now

COMMENT

Elsevier-geopolymer institute research focus on geopolymer science

29 June 2015 | Joe D'Angelo

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Elsevier-geopolymer institute research focus on geopolymer science

29 June 2015 | Joe D'Angelo

What are geopolymers?

Geopolymers are new materials for fire- and heat-resistant coatings and adhesives, medicinal applications, high-temperature ceramics, new binders for fire-resistant fiber composites, toxic and radioactive waste encapsulation and new cements for concrete. The properties and uses of geopolymers are being explored in many scientific and industrial disciplines: modern inorganic chemistry, physical chemistry, colloid chemistry, mineralogy, geology, and in other types of engineering process technologies.

Along with the discovery of the geopolymer chemistry, the research was applications driven and generated numerous patents, especially in the 1980-1990's, but few scientific papers. This is demonstrated in the number of research publications in this field; according to Scopus database, during the period from 1984-1999, there were typically between 1 to 3 publications per year (namely those of the Geopolymer Institute). The number has been steadily increasing only since year 2000. Several products are already industrialized and commercialized since the 1980's. See at the Geopolymer Institute internet, the page **Who is selling geopolymers**.

What research has been done, and where is it heading?

Environmental implications of Geopolymers

29 June 2015 | Joseph Davidovits

How should we consider geopolymers? Many scientists and civil engineers are mistaking alkali-activation for geopolymers, fuelling confusion, using them as synonyms without understanding what they really are. We find in the literature either LCAs of geopolymer cements/concretes or LCA of alkali-activated-materials. The latter encompass the specific fields of alkali-activated slags, alkali-activated coal fly ashes, alkali-activated blended Portland cement.

A dedicated Geopolymer Institute video deals with the major differences prevailing between alkali-activated-materials and geopolymer cements: *Why Alkali-Activated Materials are NOT Geopolymers?* **http://www.geopolymer.org/faq/alkali-activated-materials-geopolymers**. First, we explain the main differences between alkali-activated-concrete, alkali-activated-slag, alkali-activated-fly ash on one hand and Slag-based Geopolymer cement on the other hand, in terms of chemistry, molecular structure, long-term durability. In a second part, we comment the industrialization of Slag/fly ash-based geopolymer cement/concrete by the company Wagners, Australia, and we focus on the results provided by the

GEOPOLYMER INSTITUTE

Prof. Joseph Davidovits

WEBINARs 2013- 2014

Spring and Fall

The basics of geopolymer science

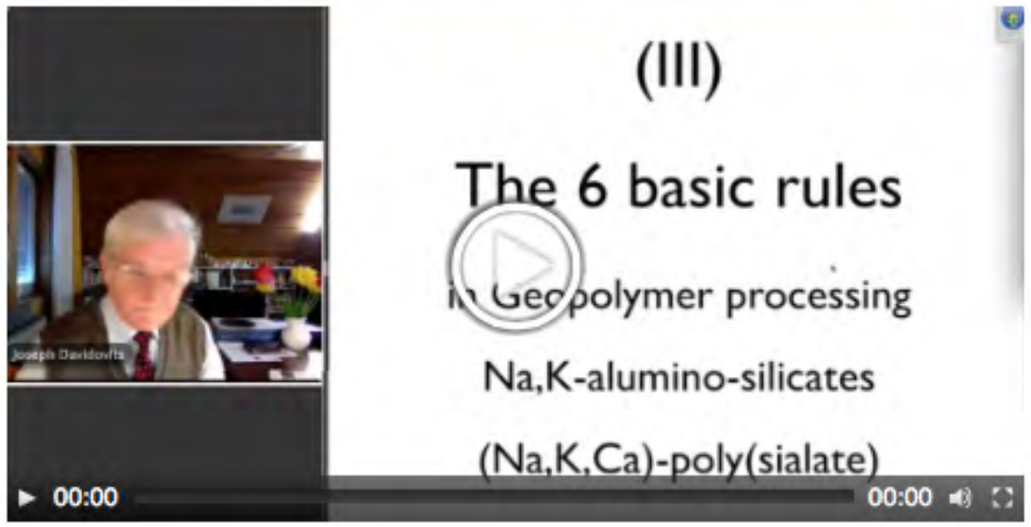
Geopolymer WEBINAR 2014

Registered Participants

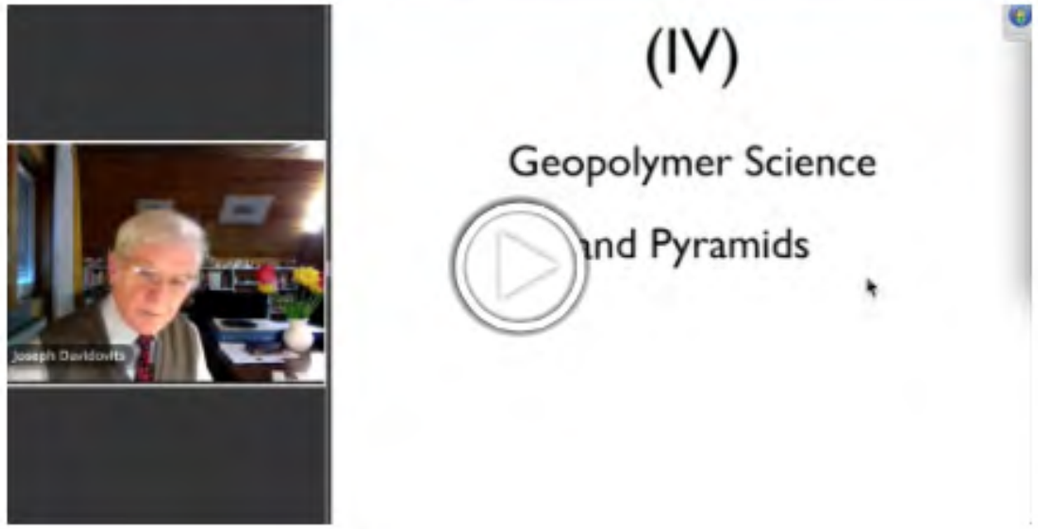
Webinar 2014 Talk 1/Part 1 – Applications and commercializations (24 min.)

Webinar 2014 Talk 1/Part 2 – What is a geopolymer ? (15 min.)

Webinar 2014 Talk 1/Part 3 – The 6 basic rules of geopolymer processing (33 min.)



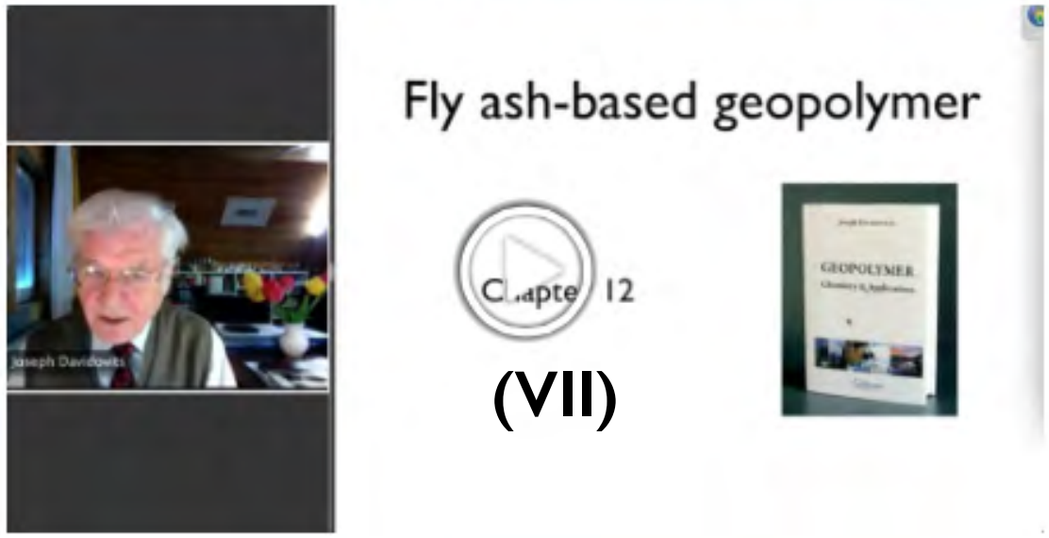
Webinar 2014 Part 4 – Geopolymer science and egyptian pyramids (25 min.)



Webinar 2014 Talk 2/Part 5 – Principles of alumino-silicate geopolymer (29 min.)

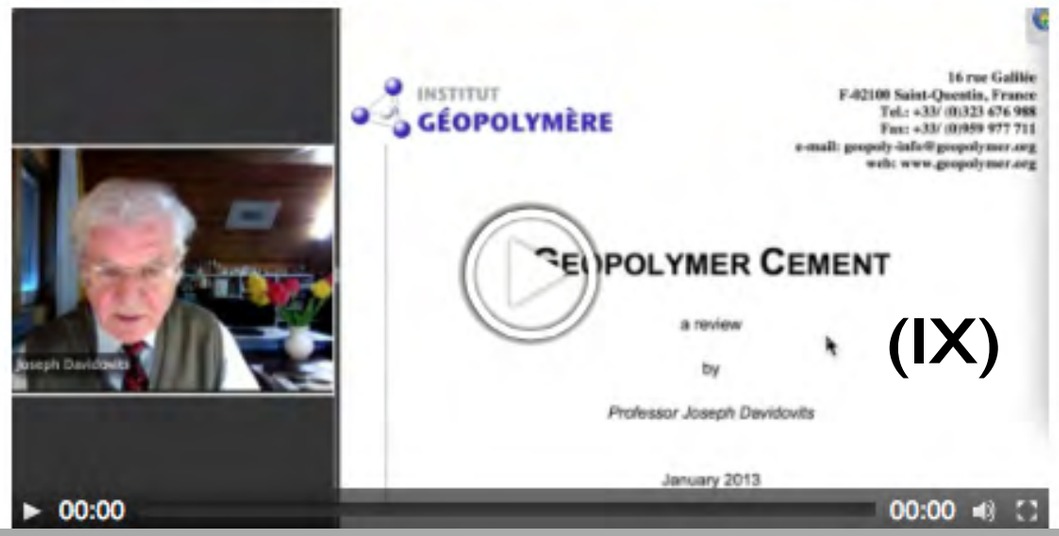
Webinar 2014 Talk 2/Part 6 – Heat- and fire-resistant geopolymer (12 min.)

Webinar 2014 Talk 2/Part 7 – Fly ashed-based geopolymer (10 min.)

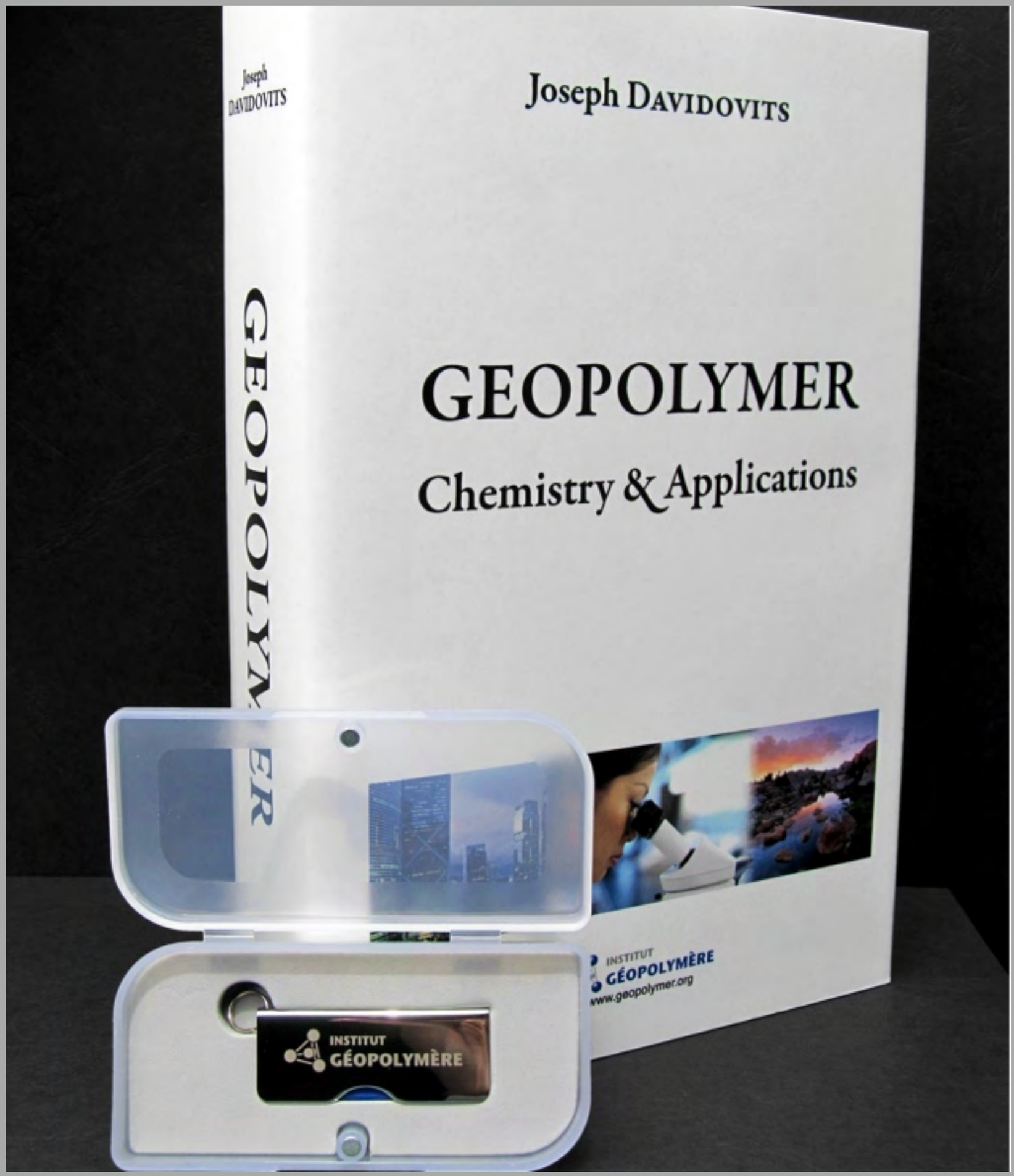


Webinar 2014 Talk 2/Part 8 – Durability tests (9 min.)

Webinar 2014 Talk 2/Part 9 – Geopolymer cement standards / low CO_2 (12 min.)



Webinar 2014 Talk 2/Part 10 – Geopolymer science and roman cement (12 min.)


Joseph DAVIDOVITS
GEOPOLYMER
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Chemistry & Applications
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Geopolymer

inorganic macromolecules

not gel, or unknown structure

alkaline polymerization

acidic polymerization

Until 1999

2nd Geopolymer Conference, GP' 99, Saint-Quentin

geopolymers = advanced knowledge in alumino-silicate chemistry

Since 2002

3rd Geopolymer Conference

GP' 2002, Melbourne

everything that is not Portland cement is called Geopolymer.

Geopolymer is not equal to AAM.

Geopolymer is not equal to AAM.

Since 2005 (Congress Geopolymer 2005, Saint-Quentin/France-Perth/Australia), I am fighting against those who use the concept of geopolymer as an interchangeable synonym for AAM.

Geopolymer is not equal to AAM.

Since 2005 (Congress Geopolymer 2005, Saint-Quentin/France-Perth/Australia), I am fighting against those who use the concept of geopolymer as an interchangeable synonym for AAM.

This is wrong.

10

Life-cycle analysis of geopolymers

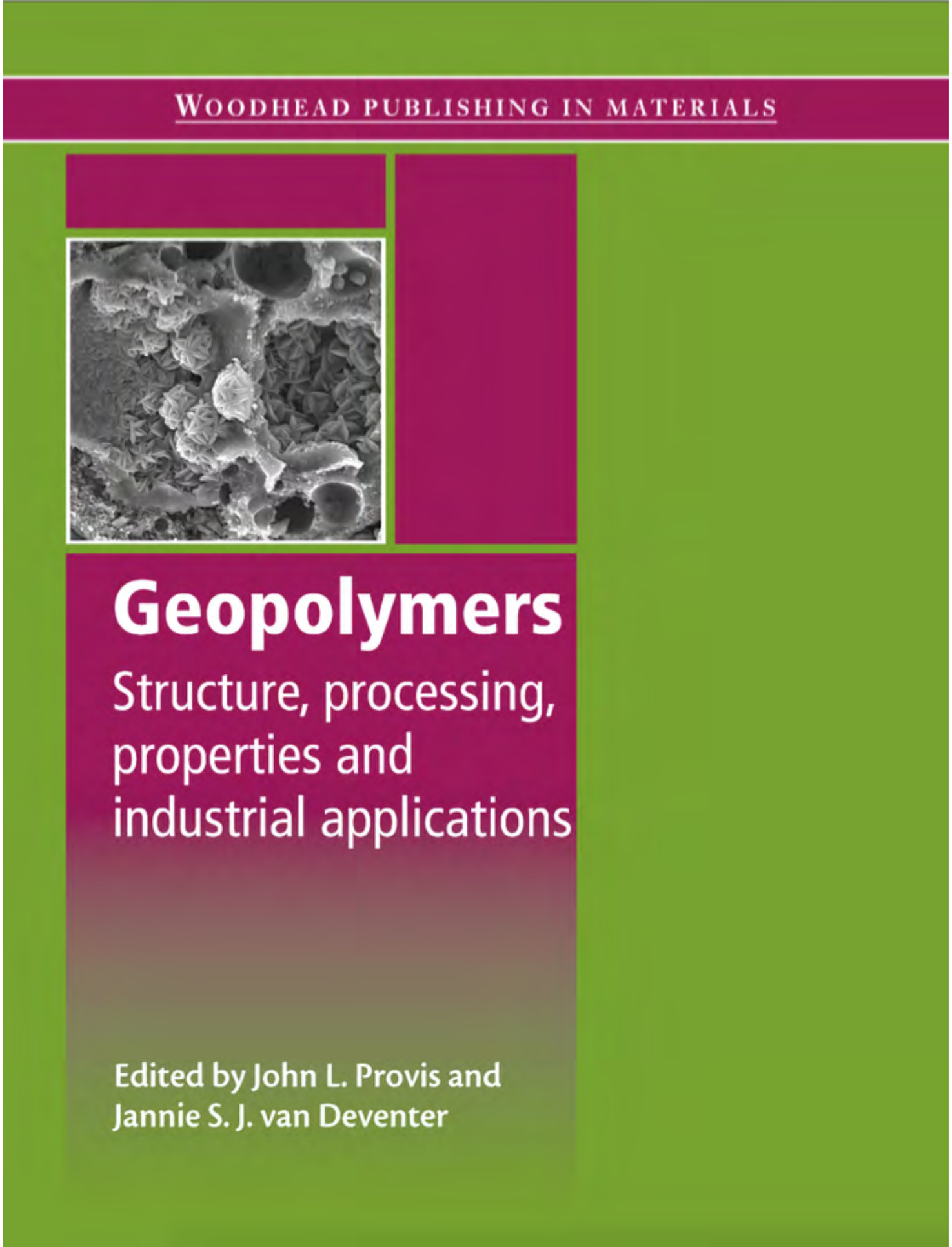
M WEIL, Institute for Technology Assessment and Systems Analysis, Germany
K DOMBROWSKI, Technische Universitat Bergakademie Freiberg, Germany and
A BUCHWALD, Bauhaus University Weimar, Germany

10.1

According to the publications of Glukhovsky, geopolymers or inorganic polymer binder systems had already emerged in the late 1960s (Glukhovsky, 1959). In Russia and the Eastern part of Europe, some industrial applications of geopolymers (e.g., railway sleepers) were reported (Petrova *et al*., 2005), but it seems that geopolymers were never in a state of mass production. Until today, only niche applications (e.g., fire-resistant glue, exhaust fume pipes, heat/fire barriers) have been established in Western Europe.

Glukhovsky worked on alkali-activation; he did not invent the geopolymer terminology and chemistry (see later).

In this paper, everything that has been implemented and commercialized in Western Europe and USA, is considered as negligible developments.


WOODHEAD PUBLISHING IN MATERIALS
Geopolymers
Structure, processing, properties and industrial applications
Edited by John L. Provis and Jannie S. J. van Deventer

2009

Every

alkali-activated waste

=

Geopolymer !!


STOP

Alkali-Activated Materials

State-of-the-Art Report, RILEM TC 224-AAM

1. Introduction and Scope

John L. Provis[1,2]

[1] Department of Materials Science and Engineering, University of Sheffield, Sheffield S1 3JD, UK*

[2] Department of Chemical & Biomolecular Engineering, University of Melbourne, Victoria 3010, Australia

1.4 Notes on terminology

keyword search on an academic search engine. In the context of this Report, the terms 'alkali-activated material (AAM)' and 'geopolymer' are at least worthy of some comment:

- Alkali activated material (AAM) is the broadest classification, encompassing essentially any binder system derived by the reaction of an alkali metal source

- Geopolymers [17] are in many instances viewed as a subset of AAMs, where the binding phase is almost exclusively aluminosilicate and highly coordinated [18,

The distinction between these classifications is shown schematically in Figure 1-2. This is obviously a highly simplified view of the chemistry of concrete-forming systems; any

Geopolymers are shown here as a subset of AAMs, with the highest Al and lowest Ca concentrations.

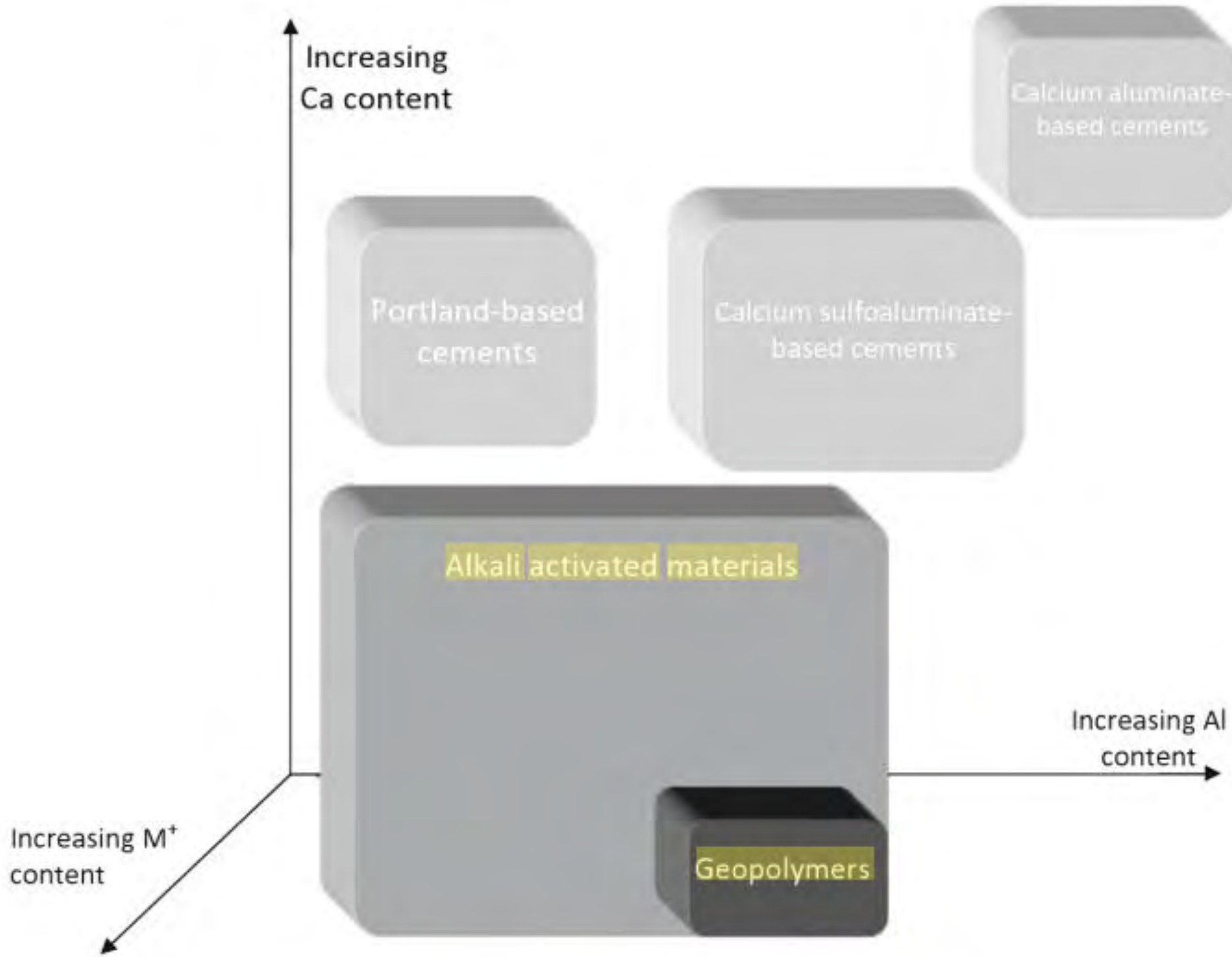


Fig. 1.2 Classification of AAMs, with comparisons to OPC and calcium sulfoaluminate binder chemistry. *Shading* indicates approximate alkali content; *darker shading* corresponds to higher concentrations of Na and/or K (Diagram courtesy of I. Beleña)

precursors used in geopolymer synthesis [22]. It is also noted that the term 'geopolymer' is also used by some workers, both academic and commercial, in a much broader sense than this; this is often done for marketing (rather than scientific) purposes.

Job Description

09 Feb. 2015

Research Associate - Geopolymer Durability

University of Sheffield View employer profile

The University Of Sheffield.

EMPLOYER:	**University of Sheffield**	POSTED:	**09-Feb-2015**
LOCATION:	**UK and Ireland**	EXPIRES:	**08-Mar-2015**
POSITION TYPE:	**Full-time**		
SALARY:	**£29,552**		

We are seeking a Research Associate within the Cements research group (Professor John Provis), in the Department of Materials Science and Engineering, University of Sheffield.

This 3-year fixed-term position is predominantly laboratory-based. The appointee will conduct research within the framework of a European Research Council-funded project, focused on analysing and optimising the durability of steel reinforcing elements within low-CO2 alkali-activated 'geopolymer' concretes, and will become a key member of a world-leading research team in the area of novel construction materials. Applicants should hold a doctoral degree in materials engineering, electrochemistry or a related field, and should be familiar with standard and advanced characterisation techniques used to analyse steels, cements and concretes. Experience in working with alkali-activated materials will be strongly advantageous.

The appointee will become a key member of a world-leading research team, and will be active in communicating research outcomes to both specialist and non-specialist audiences.

According to RILEM GEOPOLYMER is a type of CONCRETE.

Nothing else !!

WRONG


STOP

Clarifying Statement

History on geopolymer science development

Kaolinite

$Si_2O_5,Al_2(OH)_4$

- $2H_2O$

1975

Metakaolin

Si_2O_5,Al_2O_2

Alumino-silicate Oxide

KANDOXI

MK-750

1977

1st mineral polymer resin

$$
\begin{array}{l}
| \\
\text{-Si-O-Al=O} + \ n\text{SiO}_2 \ + \text{(Na,K)OH} \\
|
\end{array}
$$

MK-750 **soluble silicate**

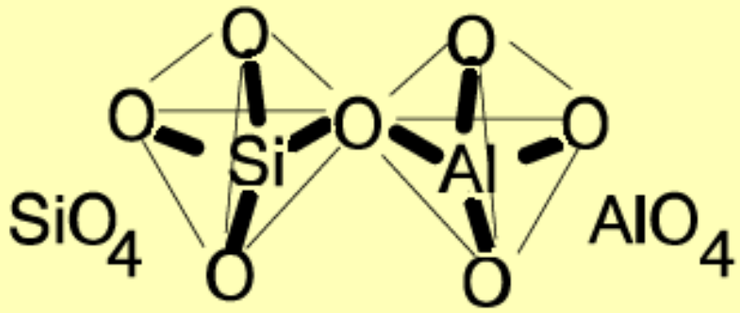

73

1979

Geopolymer Terminology

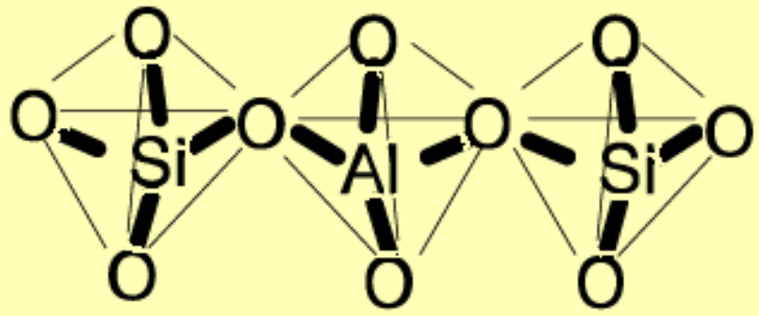
Si:Al = 1:1

Poly(sialate)
(-Si-O-Al-O-)



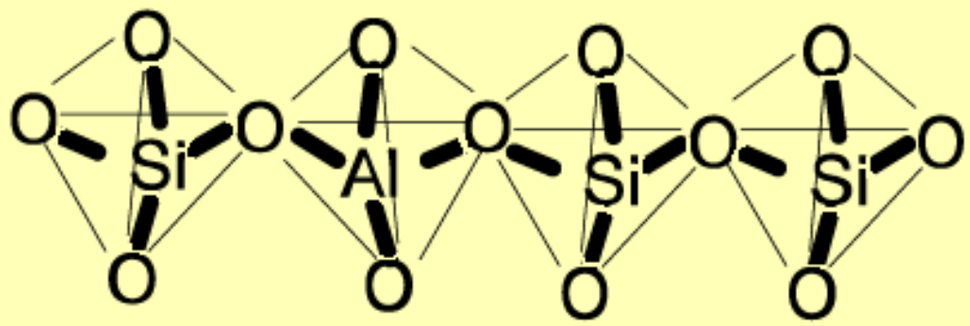
Si:Al = 2:1

Poly(sialate-siloxo)
(-Si-O-Al-O-Si-O-)



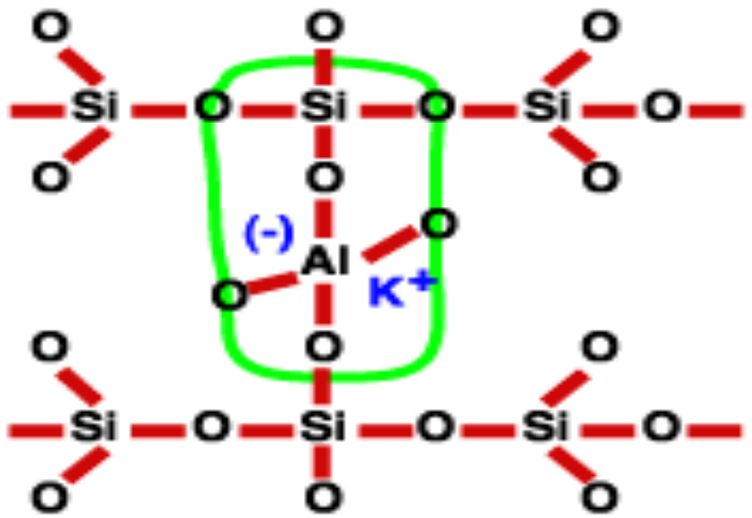
Si:Al = 3:1

Poly(sialate-disiloxo)
(-Si-O-Al-O-Si-O-Si-O-)



Si:Al >3:1

Sialate link



Geopolymers are

Polymers,

processed like

organic polymers

Yet,

GEO- polymers

Fire and heat resistant

1979

Creation of the GEOPOLYMER INSTITUTE,

Saint-Quentin, France

Non for profit scientific association

❄ ❄ ❄

The word « geopolymer » : public domain

PACTEC conference, Los Angeles, USA

❄ ❄ ❄

Cement applications !

U.S.A.

Lone Star Industries
Geopolymer cement, PYRAMENT
(1983, 11 years after begin of research, 1972)

❄ ❄ ❄

Barry University, Miami, Florida
Institute for Applied Archaeological Sciences

1st PYRAMENT patent

United States Patent [19]

Davidovits et al.

[11] **Patent Number: 4,509,985**

[45] **Date of Patent: Apr. 9, 1985**

[54] **EARLY HIGH-STRENGTH MINERAL POLYMER**

[75] Inventors: **Joseph Davidovits**, Saint-Quentin, France; **James L. Sawyer**, Friendswood, Tex.

[73] Assignee: **Pyrament Inc.**, Houston, Tex.

[21] Appl. No.: **582,279**

[22] Filed: **Feb. 22, 1984** 1984

[51] **Int. Cl.**[3] **C04B 19/04**

[52] **U.S. Cl.** **106/84**; 106/85; 106/117

[58] **Field of Search** 106/84, 85, 117

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,349,386 9/1982 Davidovits 106/85

Primary Examiner—James Poer

Attorney, Agent, or Firm—McAulay, Fields, Fisher, Goldstein & Nissen

[57] **ABSTRACT**

An early high-strength mineral polymer composition is formed of a polysialatesiloxo material obtained by adding a reactant mixture consisting of alumino-silicate oxide (Si_2O_5,Al_2O_2) with the aluminum cation in a four-fold coordination, strong alkalis such as sodium hydroxide and/or potassium hydroxide, water, and a sodium/-potassium polysilicate solution; and from 15 to 26 parts, by weight, based upon the reactive mixture of the polysialatesiloxo polymer of ground blast furnace slag. Sufficient hardening for demolding is obtained in about 1 hour with this composition.

6 Claims, No Drawings

Lone Star/PYRAMENT cement

Los Angeles: a crew begins placing geopolymer concrete.

New York: a Boing departs

1 hour	4 hours	6 hours
Strong enough to walk on	Strong enough to drive on	Ready for the weight of a commercial jet

Start March 1983 / all rights sold to Lone Star Ind. Oct. 1989

PYRAMENT PBC until 1997

MISCELLANEOUS PAPER GL-85-15

POTENTIAL APPLICATIONS OF ALKALI-ACTIVATED ALUMINO-SILICATE BINDERS IN MILITARY OPERATIONS

by

Philip G. Malone, Charlie A. Randall, Jr.

Geotechnical Laboratory

DEPARTMENT OF THE ARMY
Waterways Experiment Station, Corps of Engineers
PO Box 631, Vicksburg, Mississippi 39180-0631

and

Thaddeus Kirkpatrick

Pyrament N. V.
PO Box 2148, Houston, Texas 77252-2148

November 1985
Final Report

Prepared for DEPARTMENT OF THE ARMY
Assistant Secretary of the Army (R&D)
Washington, DC 20315
Under ILIR Project No. 4A161101A91D,
Task Area 02, Work Unit 155

1985-1986

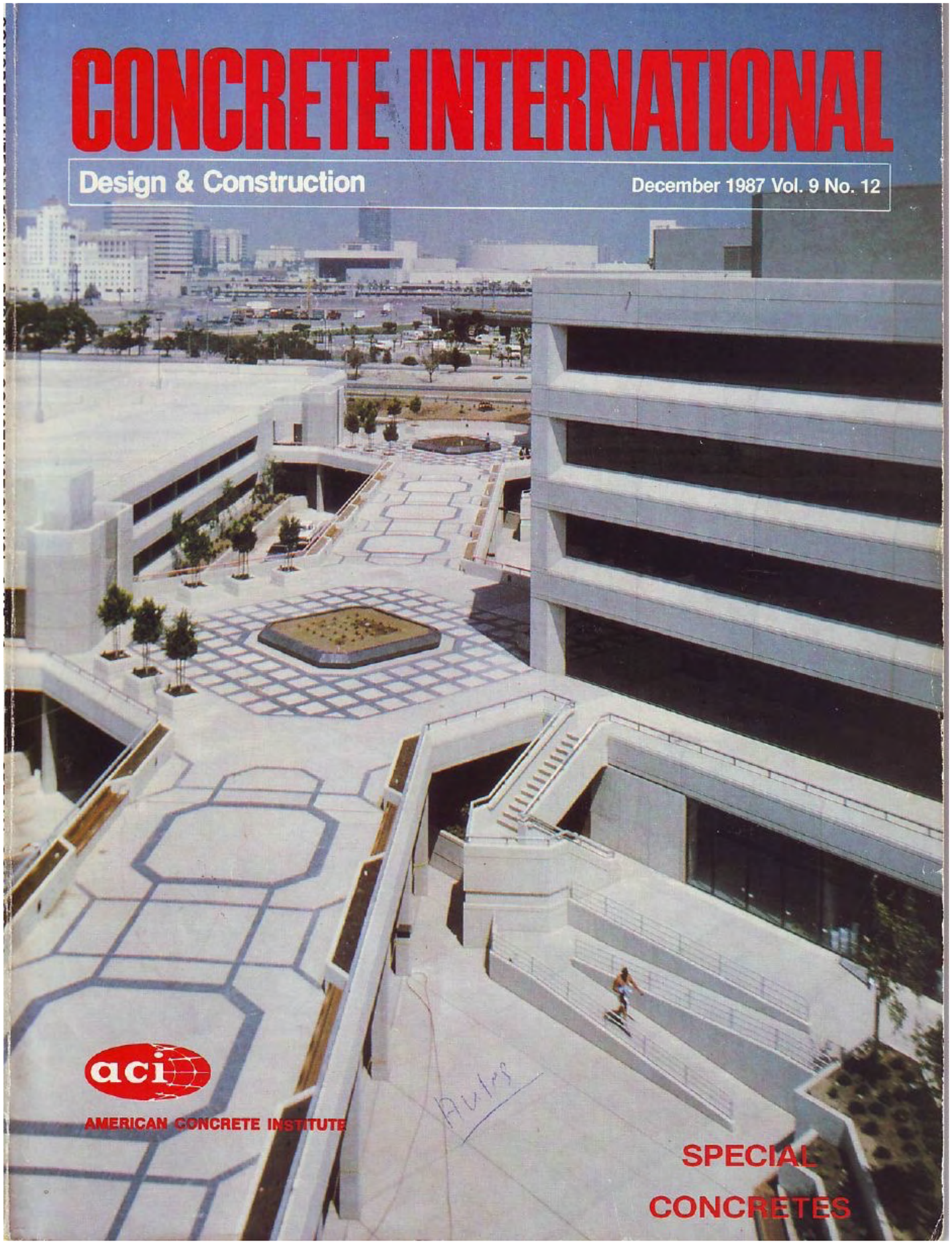
US ARMY CORPS ENGINEERS
Test of geopolymer cement PYRAMENT

Study on various alkali-activated systems,
V. Glukosvsky

14 years after

1987

1st paper on geopolymer concrete



Concrete International, dec. 1987

Geopolymeric concrete may be a key to increased durability

Ancient and Modern Concretes: What Is the Real Difference?

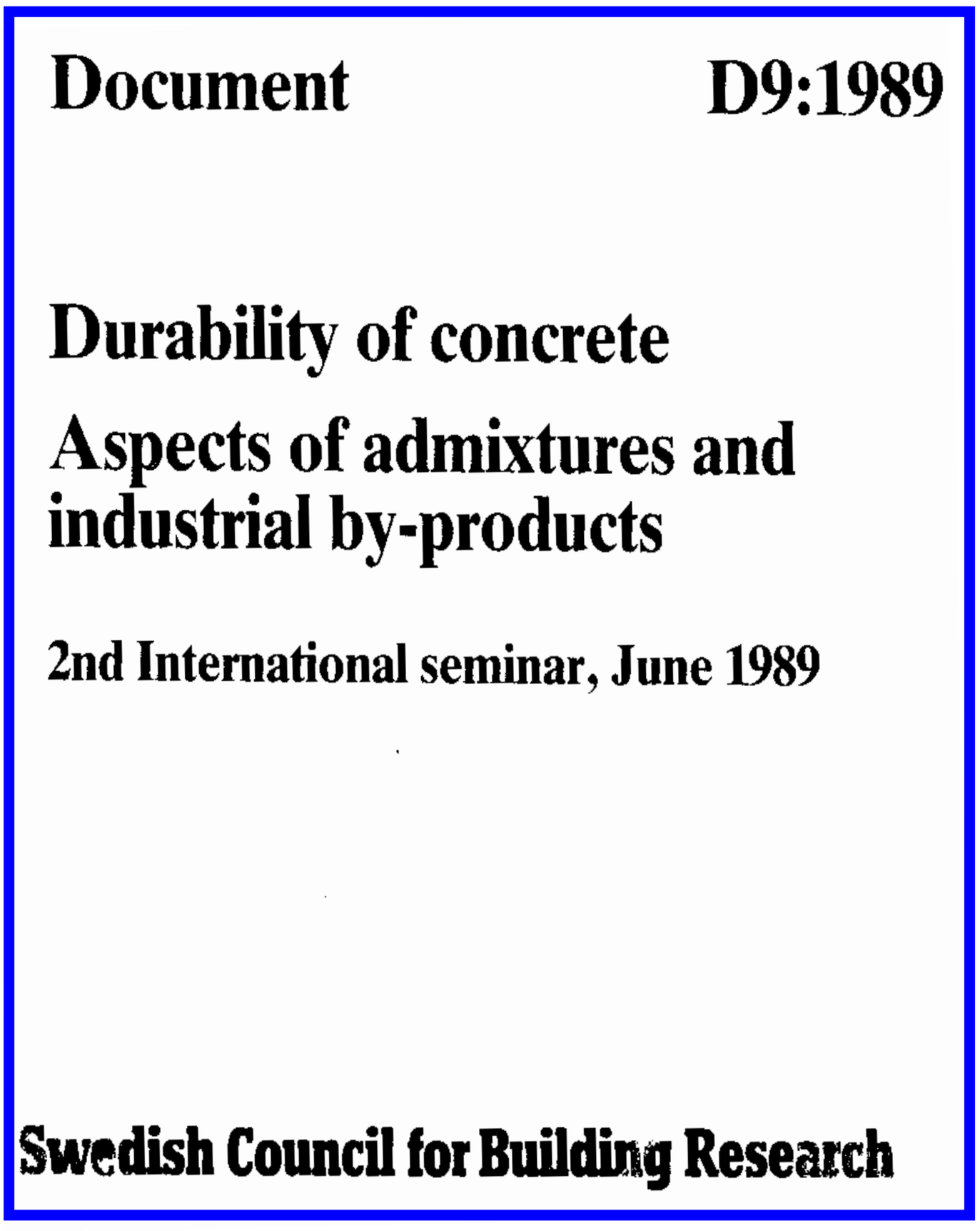
by Joseph Davidovits

Many observers of ancient architecture are struck by the vast difference in quality between original structures and more recent repairs. Recent studies have attempted to determine why ancient mortars and concretes are so much more durable than their modern counterparts. Many of these materials have been found to be geopolymeric concrete which has been replicated and may prove to be an appropriate concrete for many modern purposes.

magazine[2] dealt with a fascinating idea which would put the origin of concrete much earlier....According to this theory...to build a pyramid ....Egyptian workers could have carried crushed limestone to the work site in buckets, mixed it with Nile River silt for the needed aluminum and silicon binder, and added salts available locally as catalysts to make the solution alkaline. They could have dumped the ingredients into wooden molds and a few hours in the desert heat would have dried the mixture

same conditions. Under certain climatic conditions, some portland cement structures that are only ten years old are being severely eroded, whereas two thousand year old cement in structures in the same locations remains unaffected.

Unfortunately, only cements and mortars of surviving monuments can be investigated, since monu-


Document D9:1989

Durability of concrete

Aspects of admixtures and industrial by-products

2nd International seminar, June 1989

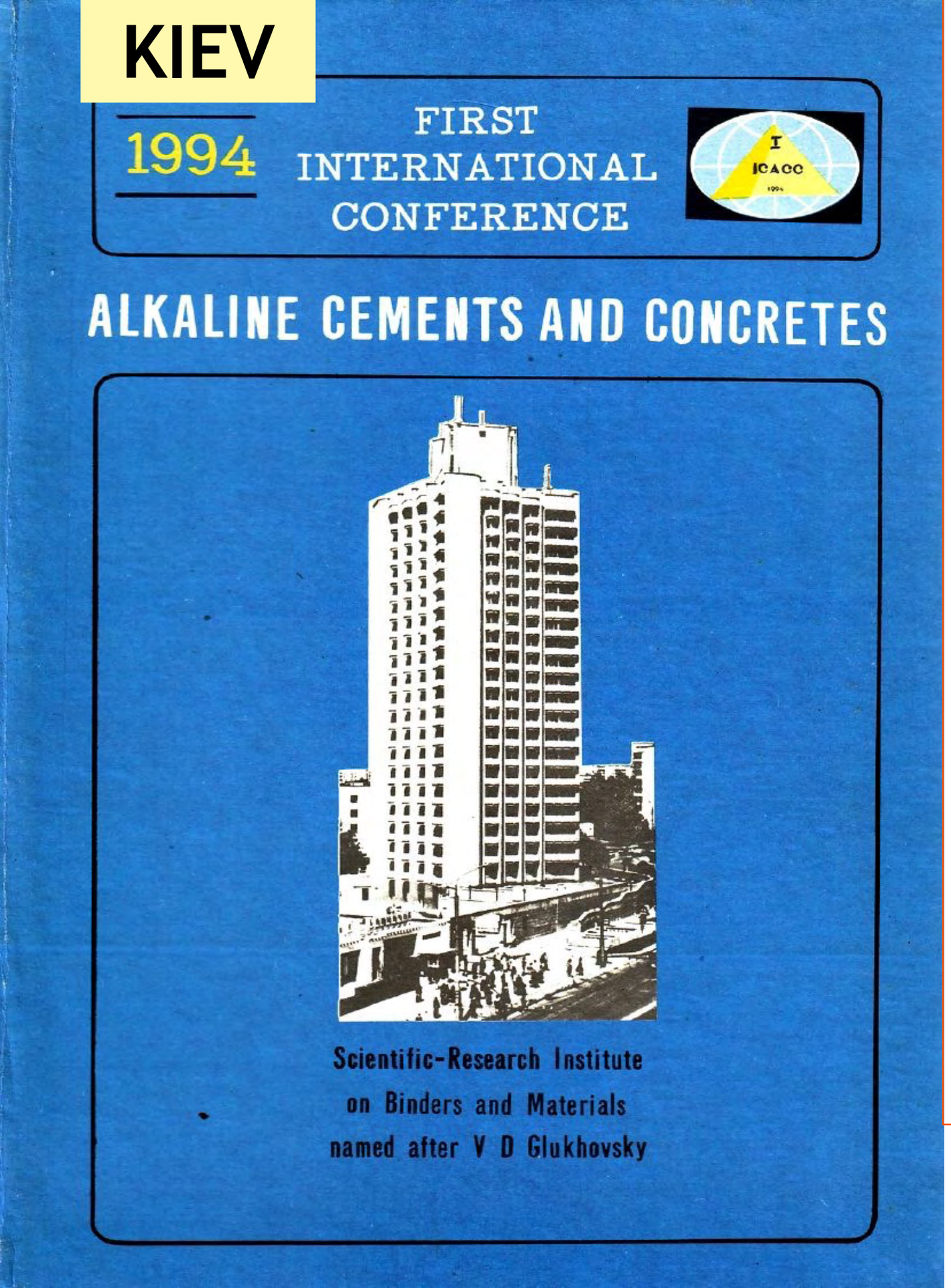
Swedish Council for Building Research

1989

Last paper by
V.D. Glukhovsky

Title:
Ancient, Modern and Future Concretes

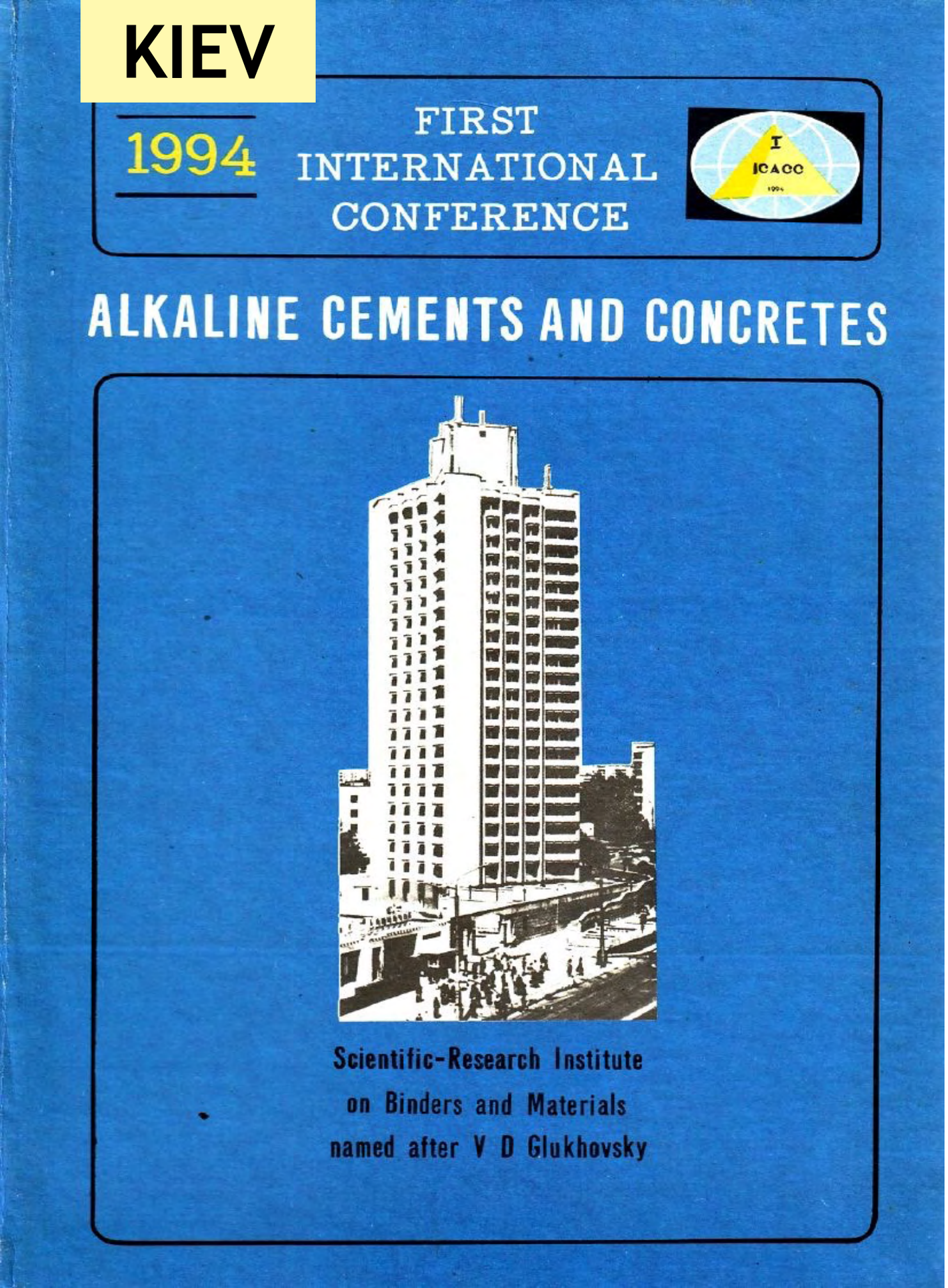
based on
J. Davidovits,
Concrete International
paper, 1987



...These compounds are similar to those commonly found in the sediments and hydrothermal metamorphous rock-forming minerals in the earth's crust, named « geopolymers » by American scientists .

Geopolymeric cement ressembles the alkali-alkaline Soil-cements....

V.D. Glukhovsky



…Kiev scientists learned about the excellent durability and long-term properties of geopolymer cements, due to the reaction with metakaolin MK-750.

They used Davidovits' work on geopolymer cement to improve the quality of their alkali-activated material *and coined it*:

Geo-cement.

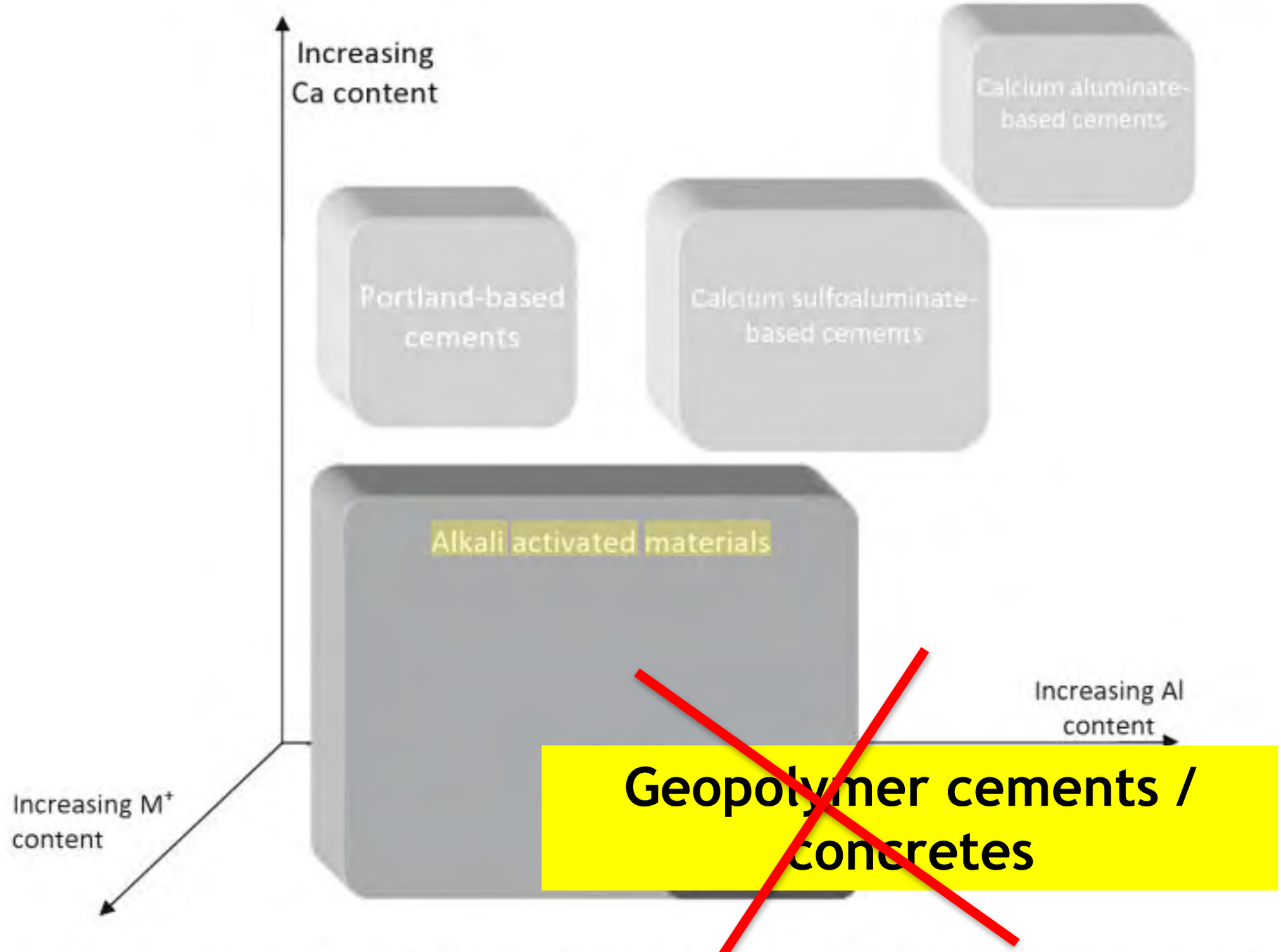
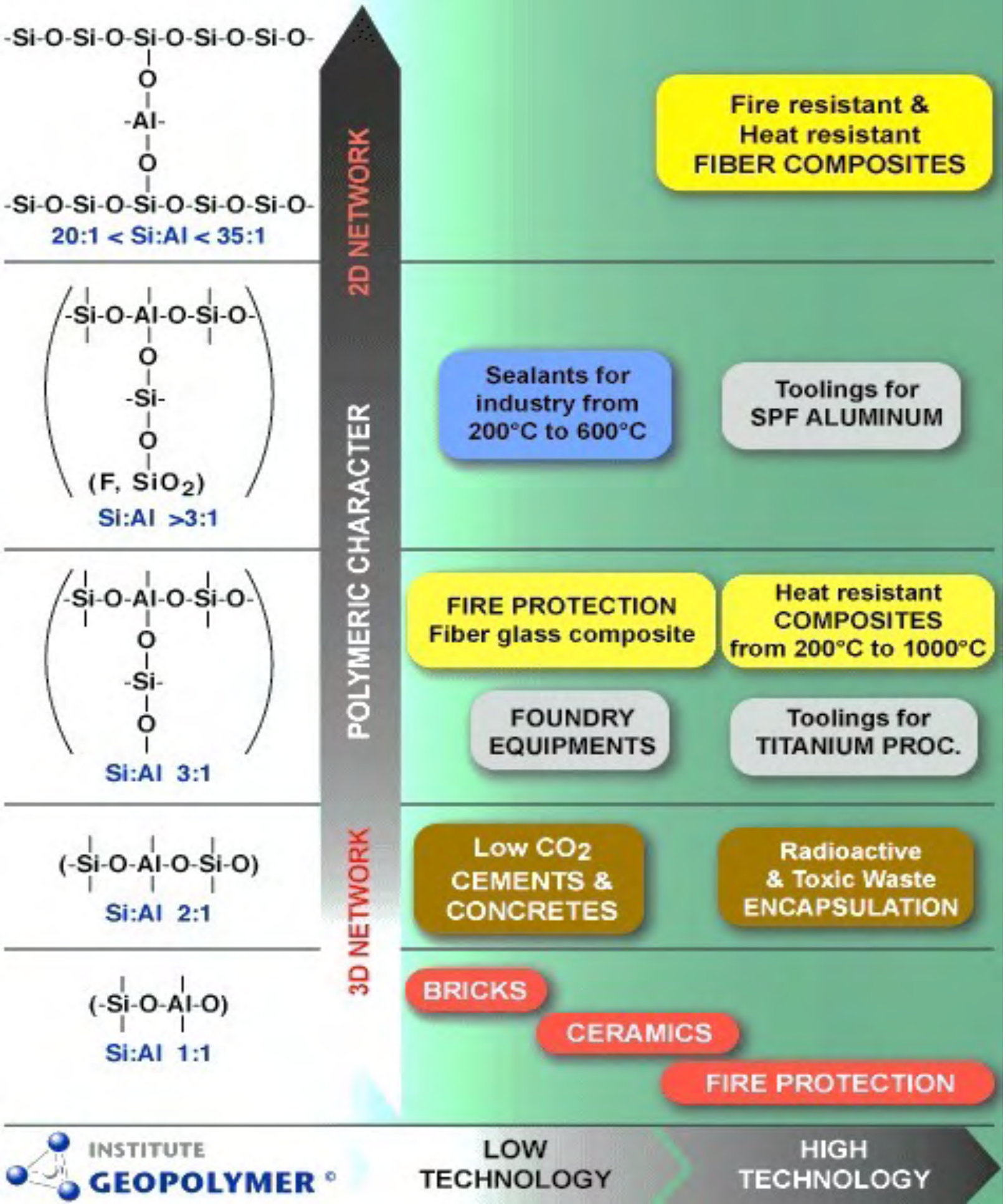
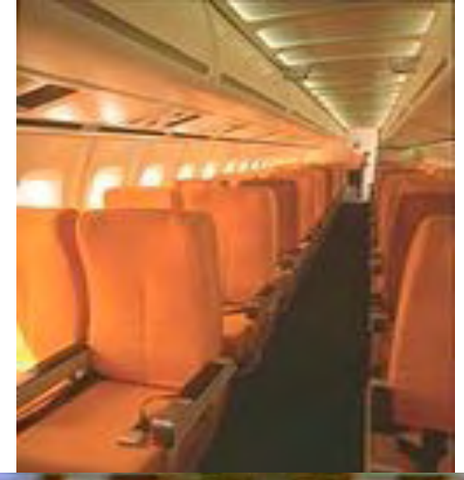


Fig. 1.2 Classification of AAMs, with comparisons to OPC and calcium sulfoaluminate binder chemistry. *Shading* indicates approximate alkali content; *darker shading* corresponds to higher concentrations of Na and/or K (Diagram courtesy of I. Beleña)


-Si-O-Si-O-Si-O-Si-O-Si-O-
O
-Al-
O
-Si-O-Si-O-Si-O-Si-O-Si-O-
20:1 < Si:Al < 35:1
-Si-O-Al-O-Si-O-
O
-Si-
O
(F, SiO2)
Si:Al >3:1
-Si-O-Al-O-Si-O-
O
-Si-
O
Si:Al 3:1
(-Si-O-Al-O-Si-O)
Si:Al 2:1
(-Si-O-Al-O)
Si:Al 1:1
2D NETWORK
POLYMERIC CHARACTER
3D NETWORK
Fire resistant & Heat resistant FIBER COMPOSITES
Sealants for industry from 200°C to 600°C
Toolings for SPF ALUMINUM
FIRE PROTECTION Fiber glass composite
Heat resistant COMPOSITES from 200°C to 1000°C
FOUNDRY EQUIPMENTS
Toolings for TITANIUM PROC.
Low CO2 CEMENTS & CONCRETES
Radioactive & Toxic Waste ENCAPSULATION
BRICKS
CERAMICS
FIRE PROTECTION
INSTITUTE GEOPOLYMER ©
LOW TECHNOLOGY
HIGH TECHNOLOGY




MILD SEVEN
RENAULT elf
BENETTON SPORTSYSTEM
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GEOPOLYMER INSTITUTE

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SCIENCE

Innovation and further researches

Posted by: Editor on Apr 5, 2006 | No Comments

Prof. Joseph Davidovits presents the road map for the next couple of years on geopolymer science innovation and research, at the 2nd International Congress on Ceramics, Verona, Italy, July 4th, 2008.

Road map R&D presented at *2nd International Congress on Ceramics*, Verona, Italy, July 4th, 2008.

15 research topics

#1 Polymeric character of geopolymers:

#2 Poly(siloxonate), soluble silicate (water-glass)

#3 Metakaolin MK-750-based geopolymer

#4 Calcium-based geopolymer

#5 Rock-based geopolymer

#6 Silica-based geopolymer

#7 Fly ash-based geopolymer

#8 Phosphate-based geopolymer

15 research topics

#9 Organic-mineral geopolymer:

#10 Long-term durability

#11 Geopolymer-fiber composites:

#12 Geopolymer in ceramic processing

#13 The manufacture of geopolymer cements

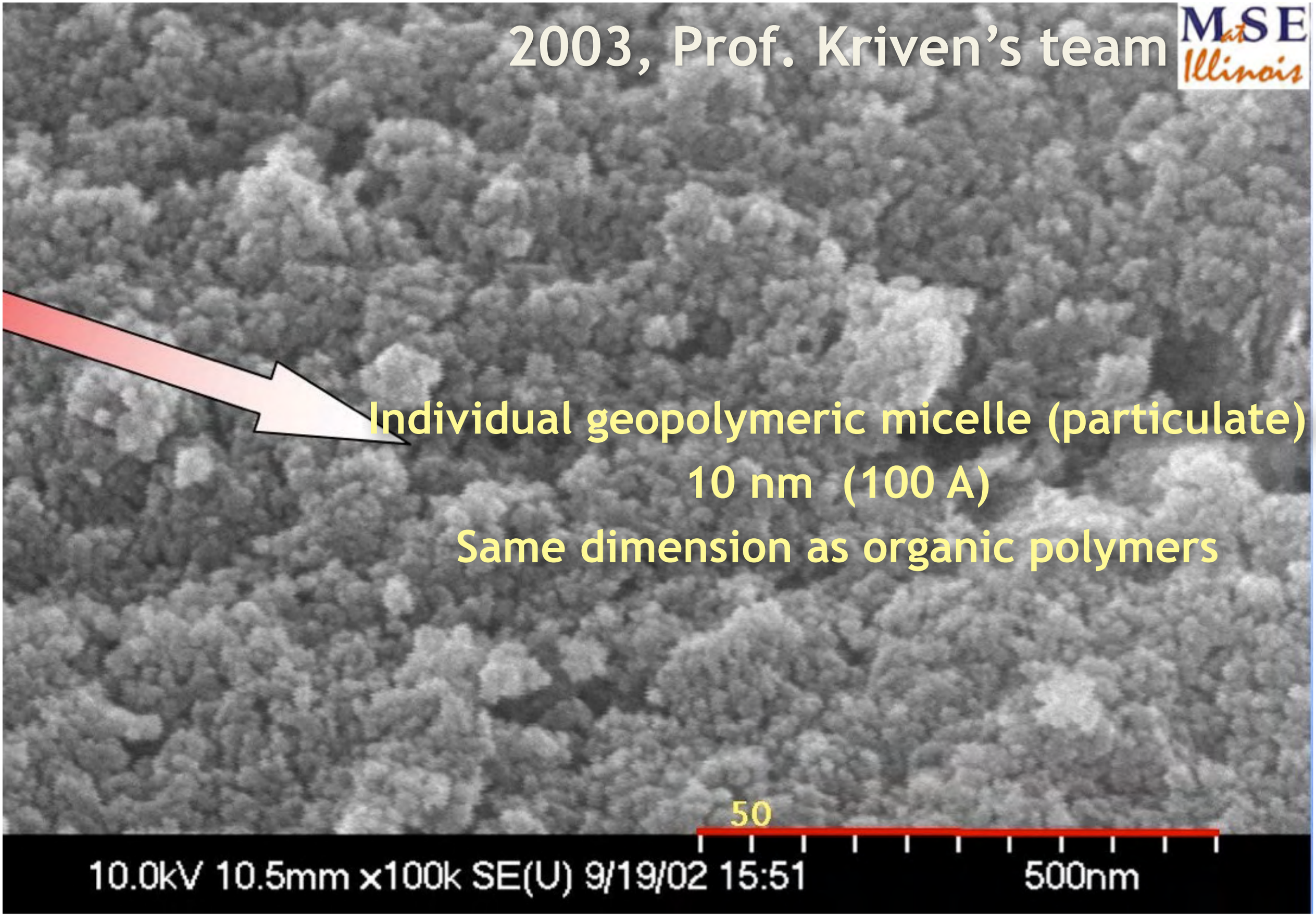
#14 Geopolymer concrete

#15 Material for medicinal applications

15 research topics

#1 Polymeric character of geopolymers:

geopolymer micelles or nanoparticulates


2003, Prof. Kriven's team
MatSE Illinois
Individual geopolymeric micelle (particulate)
10 nm (100 A)
Same dimension as organic polymers
50
10.0kV 10.5mm x100k SE(U) 9/19/02 15:51
500nm

Colloidal
silica
30-40 nm

GP-micelle
10 nm

Silica Fume
200-300 nm

Fly ash
3-15 μ

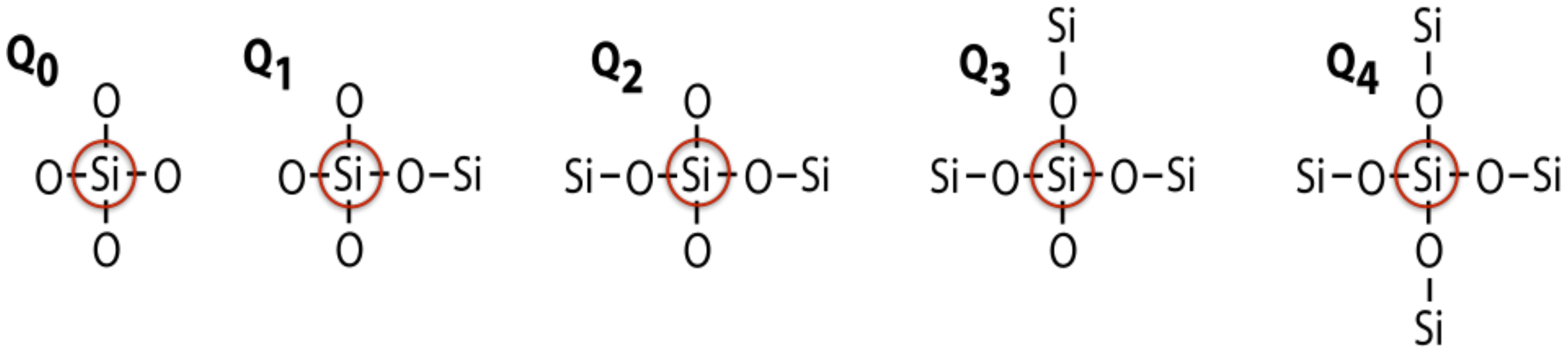
Geopolymer = nano material
not unknown « Gel »

15 research topics

#2 Poly(siloxonate), soluble silicate (water-glass):

➢*study ESPCI-ParisTech, microsilica-based (silica fume)*

➢*Si speciations in Na-silicate solutions*



State of the Geopolymer R&D 2014

2014 GeopolymerCamp

Joseph Davidovits

15 research topics

#3 Metakaolin MK-750-based geopolymer:

synthetic MK-750 (3 methods)

#4 Calcium-based geopolymer

alkali-activation vs geopolymerization

See Video « *Why alkali-activated materials are not geopolymers* »

15 research topics

#5 Rock-based geopolymer

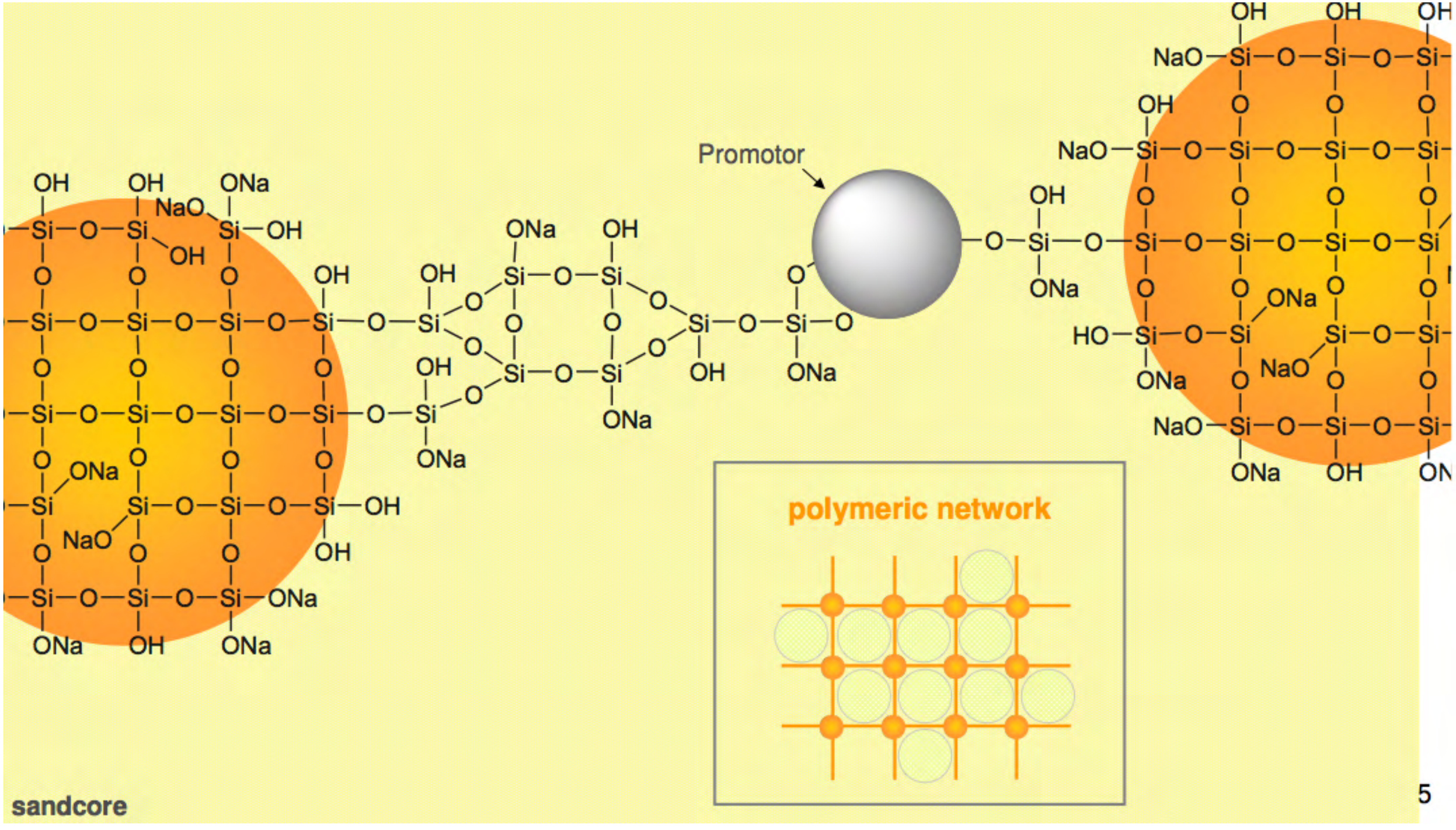
Ferro-sialate (-Fe-O-Si-O-Al-O-)

#6 Silica-based geopolymer

nano-poly(silanol)

Silica-based geopolymer resin (Na,K)nano-poly(silanol)

(*Chap. 11*)



adapted from INOTEC binding system, ASK Chemicals

15 research topics

#7 Fly ash-based geopolymer

no alkali-activated fly ash (user hostile)

#8 Phosphate-based geopolymer:

AlPO4 isomorphs

#9 Organic-mineral geopolymer:

phenolic, water-based latex, ethyl ester silicate

silane, epoxy,

compatibility rule: Napoli Parthenope Univ.

Contents lists available at SciVerse ScienceDirect

Applied Clay Science

2013

journal homepage: www.elsevier.com/locate/clay

Research paper

Novel hybrid organic-geopolymer materials

Claudio Ferone [a], Giuseppina Roviello [a,*], Francesco Colangelo [a], Raffaele Cioffi [a], Oreste Tarallo [b]

[a] *Dipartimento per le Tecnologie, Facoltà di Ingegneria, Università di Napoli 'Parthenope', INSTM Research Group Napoli Parthenope, Centro Direzionale Napoli, Isola C4, 80143 Napoli, Italy*
[b] *Dipartimento di Scienze Chimiche, Università degli Studi di Napoli "Federico II", Complesso Universitario di Monte S. Angelo, via Cintia, 80126 Napoli, Italy*

Epoxy resin + MK-750-based Poly(sialate-siloxo):

- good compatibility between the organic and the aqueous inorganic phases is obtained thanks to the *numerous hydroxyl tails (-OH)* formed during the epoxy ring opening reaction that make the organic phase "*temporarily hydrophilic*" increasing the compatibility with the aqueous inorganic phase.

Section 8.5.1 GP-Book

Napoli Parthenope Univ.

condensation

Na-poly(sialate)
Nepheline framework

epoxy group

(6)

15 research topics

#10 Long-term durability

Roman cement: sialate link

#11 Geopolymer-fiber composites:

high-temperature up to 1300°C, flax fiber

#12 Geopolymer in ceramic processing

high temperature ceramics (Cs, Li, Ga, Ge)

#13 The manufacture of geopolymer cements

reduction of K-silicate amount

(K-Ca) geopolymer cements

Evolution since 1983-85.

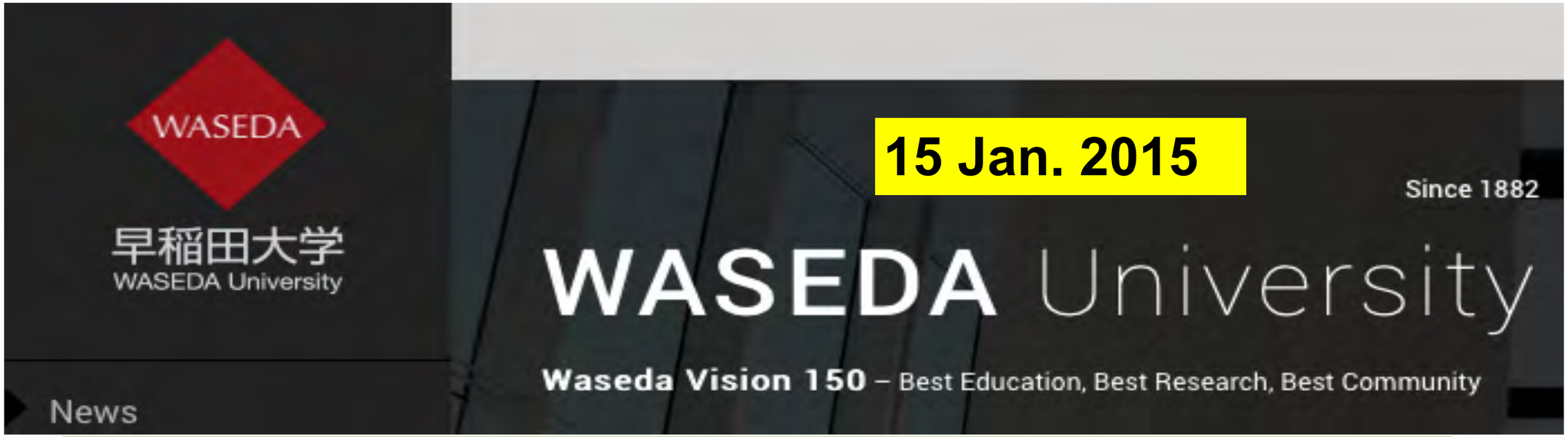
K-silicate % by weight of geopolymeric formulation

Pyrament (1985)	Geopolymite 50 (1987)	Rock-based (1997) 100 MPa	Rock-based (2002) 50 MPa	Fly Ash-based (2006) 100 MPa	Fly Ash-based (2006) 40 MPa
50 %	50 %	20 %	17 %	14 %	10 %

#14 Geopolymer concrete

First structural geopolymer concrete (Brisbane, Wagners)

#15 Radioactive and nuclear waste



New decontamination tool – Catenacio PA expected to help Fukushima clean up

RISET developed this material after its attention was drawn to the cation exchange capacity (CEC) of geopolymer. Noting the material's CEC level, the researchers decided to make use of this feature. *Catenaccio PA* is expected to make a significant contribution towards improved safety not only through its use in the treatment of contaminated water from nuclear power plants.

(6) Issues for the future

Since this adsorbent has only been developed recently, although its basic functions have been confirmed in the laboratory, full performance assessments against a variety of real-life effluents have not yet been undertaken. It is planned to deliver samples of the adsorbents for assessment by a third party beginning in January 2015.

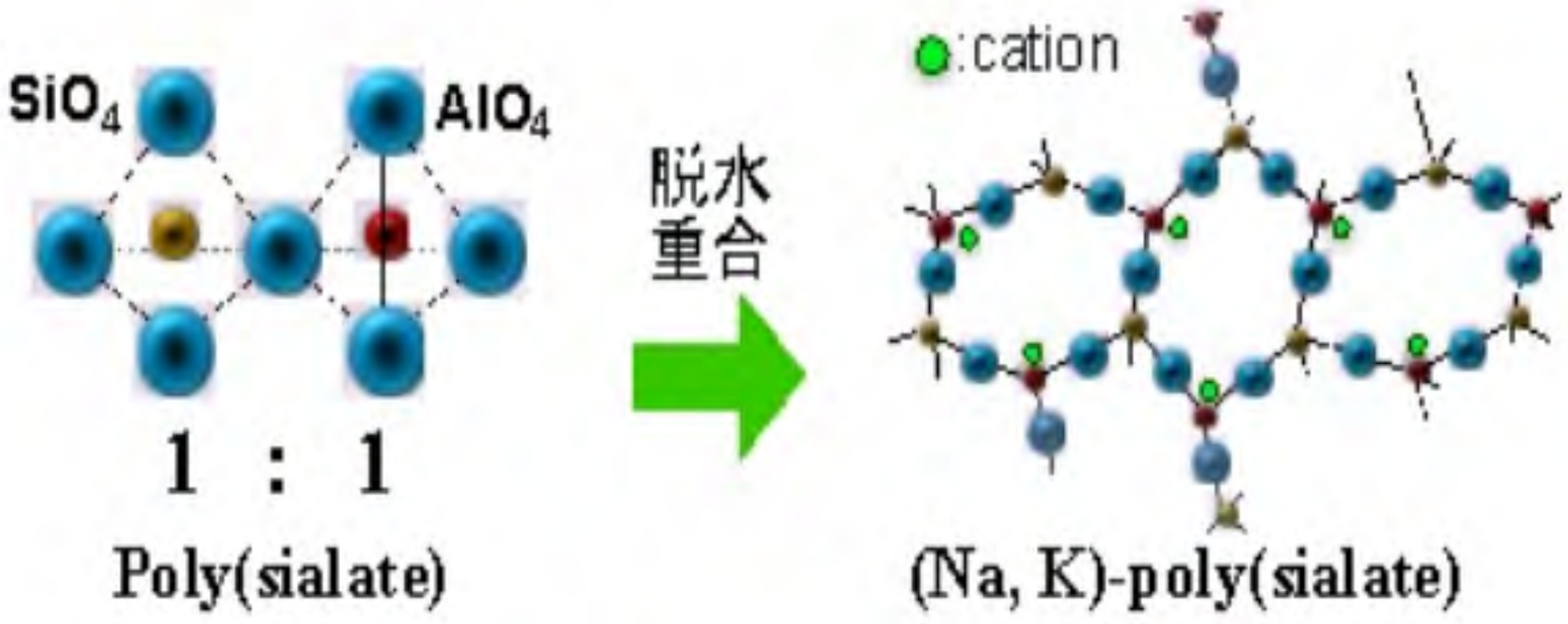


Fig. 1: Structural pattern of geopolymer-based adsorbents

State of the Geopolymer R&D 2015

1) Geopolymer science

2) Geopolymer technologies

3) Geopolymer Cements / Concretes

4) Geopolymer and archaeology

Journal of
Ceramic Science
and Technology

J. Ceram. Sci. Tech., **06** [02] 105-112 (2015)
DOI: 10.4416/JCST2014-00057
available online at: http://www.ceramic-science.com

Porous Geopolymer Components through Inverse Replica of 3D Printed Sacrificial Templates

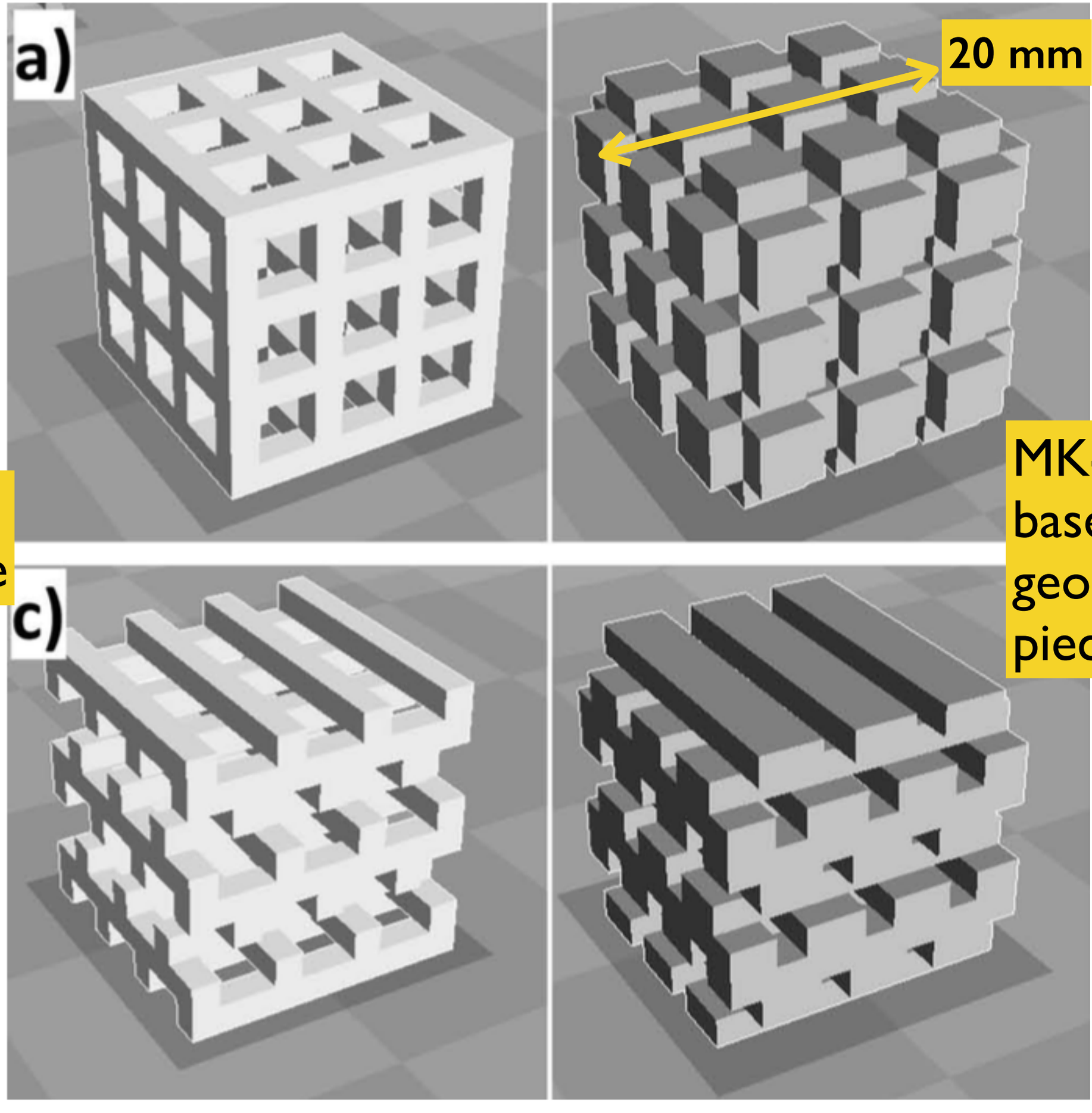
G. Franchin*[1], P. Colombo[1, 2]

[1]Department of Industrial Engineering, University of Padova, Via Marzolo 9, 35131 Padova, Italy
[2]Department of Materials Science and Engineering, The Pennsylvania

Abstract

Geopolymeric components with high controlled porosity were designed and produced by means of CAD/CAM and FDM (Fused Deposition Modeling) techniques. PLA (Poly-lactic-acid) sacrificial structures with different patterns were 3D printed with high accuracy and a geopolymeric slurry was used to produce close inverse replicas……

PLA template



MK-750-based geopolymer pieces

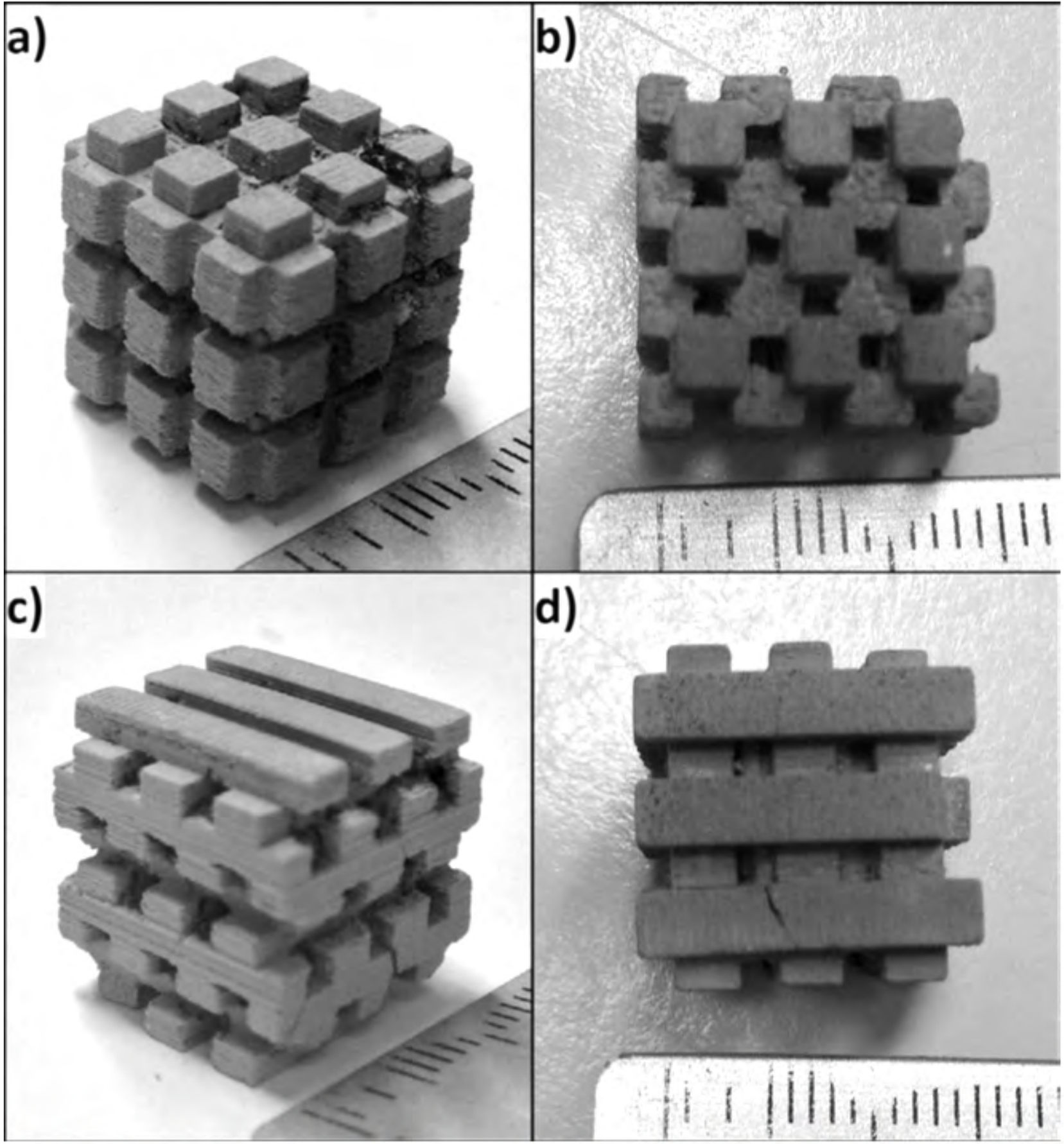
Method

Fused Deposition Modeling (FDM) 3D printer…A Poly(Lactic Acid) (PLA) filament (3 mm diameter) was used to print the molds with a resolution of 0.1mm in the Z direction (which determines the height of each layer) and of 0.35 mm in the X,Y directions, corresponding to the nozzle diameter.

The external shape of the final lattice was a cube with 15-mm sides; molds were designed to have open interconnected channels of (WxH) 3x3 mm or1.5x3mm…

PLA sacrificial templates impregnated with MK-750/Fly ash-based geopolymer slurry. Sealed, hardening at RT for 72 hours. After hardening, the sacrificial PLA templates is removed: directly immersed in KOH 15M at a temperature of 72 °C for 24 h, nucleophilic attack of the polymer chain links, partial hydrolysis.

Samples were then washed with hot water to extract the PLA. Subsequently, the samples were heat-treated at 330 °C for 24 h in a tube furnace under an air flux.: complete PLA removal and retention of the geopolymer integrity.



MK-750-based geopolymer cubes l 5-mm sides

Fig. 2: Inverse replica of the four lattices after complete PLA degradation.

Geopolymer Camp 2014 Keynote

SAND TEAM
partner pro jádra a formy

GEOPOL®

The technology of mould and core production with geopolymer binder system

Practical using in foundry industry

Ing. Zdeněk Krahula

State of the Geopolymer R&D 2014

1) Geopolymer science

2) Geopolymer technologies

3) Geopolymer Cements / Concretes

4) Geopolymer and archaeology

Milliken

GeoPolymer

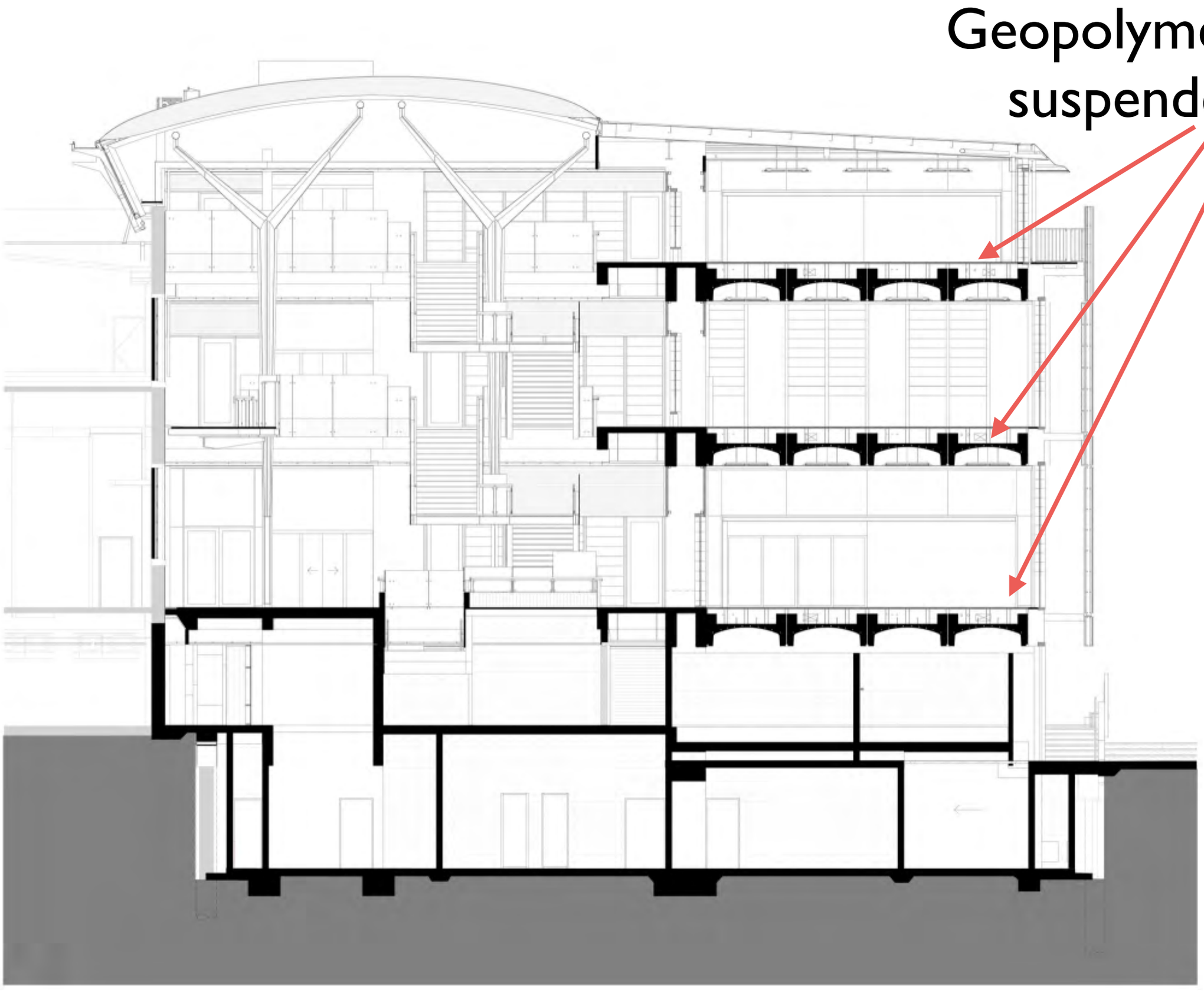
Mortar Solutions


Timor Sea
Northern Territory
Queensland
Australia
Western Australia
South Australia
Brisbane
Gold Coast
Perth
New South Wales
Sydney
Adelaide
Great Australian Bight
Victoria
Melbourne

UNIVERSITY OF QUEENSLAND GLOBAL CHANGE INSTITUTE

Global Change Institute ($32 million building designed by HASSELL) ... zero-energy and carbon neutral workplace.

The University of Queensland's Global Change Institute (GCI), designed by HASSELL in conjunction with Bligh Tanner and Wagners, is the world's first building to successfully use geopolymer concrete for structural purposes.


Geopolymer concrete
suspended floors

UNIVERSITY OF QUEENSLAND GLOBAL CHANGE INSTITUTE

UNIVERSITY OF QUEENSLAND GLOBAL CHANGE INSTITUTE

UNIVERSITY OF QUEENSLAND GLOBAL CHANGE INSTITUTE

3 floors: 33 precast panels of

slag/fly ash-based geopolymer concrete

Runways + Taxiways + Buildings

West Brisbane Wellcamp Airport Site

EFC geopolymer concrete batch plant

Turning node + Aprons + Taxiways

+ Hangars

= 50,500 m² ; 43.5 cm thick

NEWS

70,000 tonnes Geopolymer Concrete for airport

Updated on Oct 14, 2014

In Australia, on September 28, 2014, the newly complete Brisbane West Wellcamp airport (BWWA) held a community open day.

Credit: [The Chronicle 29 Sept. 2014]

« The greenest airport in the world. More than 30,000 cubic metres of the world's lowest carbon, cement-free ***geopolymer concrete****, Wagners' Earth Friendly Concrete (EFC)*, … »

Question : why so long ?

1983 - 2013 = 30 years

2013

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GEOPOLYMER CEMENT

a review

by

Professor Joseph Davidovits

January 2013

The existing Portland cement standards are not adapted to geopolymer cements. They must be created by an *ad hoc* committee. Yet, to do so, requires also the presence of standard geopolymer cements.

Presently, every expert is providing his own recipe based on local raw materials (wastes, by-products or extracted).

There is a need for selecting the right geopolymer cement category.

The 2012 State of the Geopolymer R&D, suggested to select two categories, namely:

- *Slag/fly ash-based geopolymer cement*: fly ashes are available in the major emerging countries;
- *Rock-based geopolymer cement:* this geological iron rich raw material is present in all countries through out the globe.

Technical data on Wagners' geopolymer concrete

- *First category:*
  - *slag/fly-ash based geopolymer cement*

Engineering Properties of a Proprietary Premixed Geopolymer Concrete

James M Aldred

Technical Director, AECOM

Aldred, J., 2013, "Engineering Properties of a Proprietary Premixed Geopolymer Concrete", Proceedings Concrete Institute of Australia Biennial Conference, Concrete 2013 – Understanding Concrete, Gold Coast, Australia.

Geopolymer concrete has been extensively studied by various universities and is starting to gain acceptance in a range of different applications. There are many publications discussing different properties of geopolymer synthesised from different raw materials and activators.

Product information sheets, and even technical papers, may present positive data obtained from different binder chemistries giving the misleading impression that a specific proprietary material has been comprehensively tested when it has not.

Alternatively papers may also focus on a particular material with poor performance to negatively characterise geopolymers [*i.e. alkali-activation*].

One common concern raised by designers regarding the use of geopolymer concrete, is compliance with the relevant Australian Standards. Standards necessarily develop from the established construction materials and practices which can inhibit the use of innovative materials and procedures.

Generally, National Standards and Codes which are more prescriptive in nature and explicitly limit concrete to a Portland cement based binder are an *impediment* to non-Portland based binders being accepted in the industry.

a hindrance or obstruction in doing something

European concrete standard EN 206 includes an equivalent performance concept, but there is a restriction that potential binders should comply with *European cement standard* EN 197 and therefore would technically exclude geopolymers which do not contain Portland cement clinker.

Australian Standard for Concrete Structures (AS 3600) does not specify Portland cement based concrete. The components of the Standard are primarily ***performance based***.

In USA, recent adoption of **ASTM C1157**, *Performance Specification for Hydraulic Cement* (the first version of ASTM C1157 appeared in 2000), represents an important development in this area.

ASTM C1157 simply requires that the cement meet physical performance test requirements.

The use of ASTM C1157 is being implemented on a small number of projects to evaluate its effectiveness. The Colorado DOT has been a leader in the use of performance-specified cements and has used them on a number of highway projects.

Establish standards for global economy:

max. 2 universal and «User-friendly»

geopolymeric processes

1) (Na,K,Ca)-fly ash-based geopolymer cement

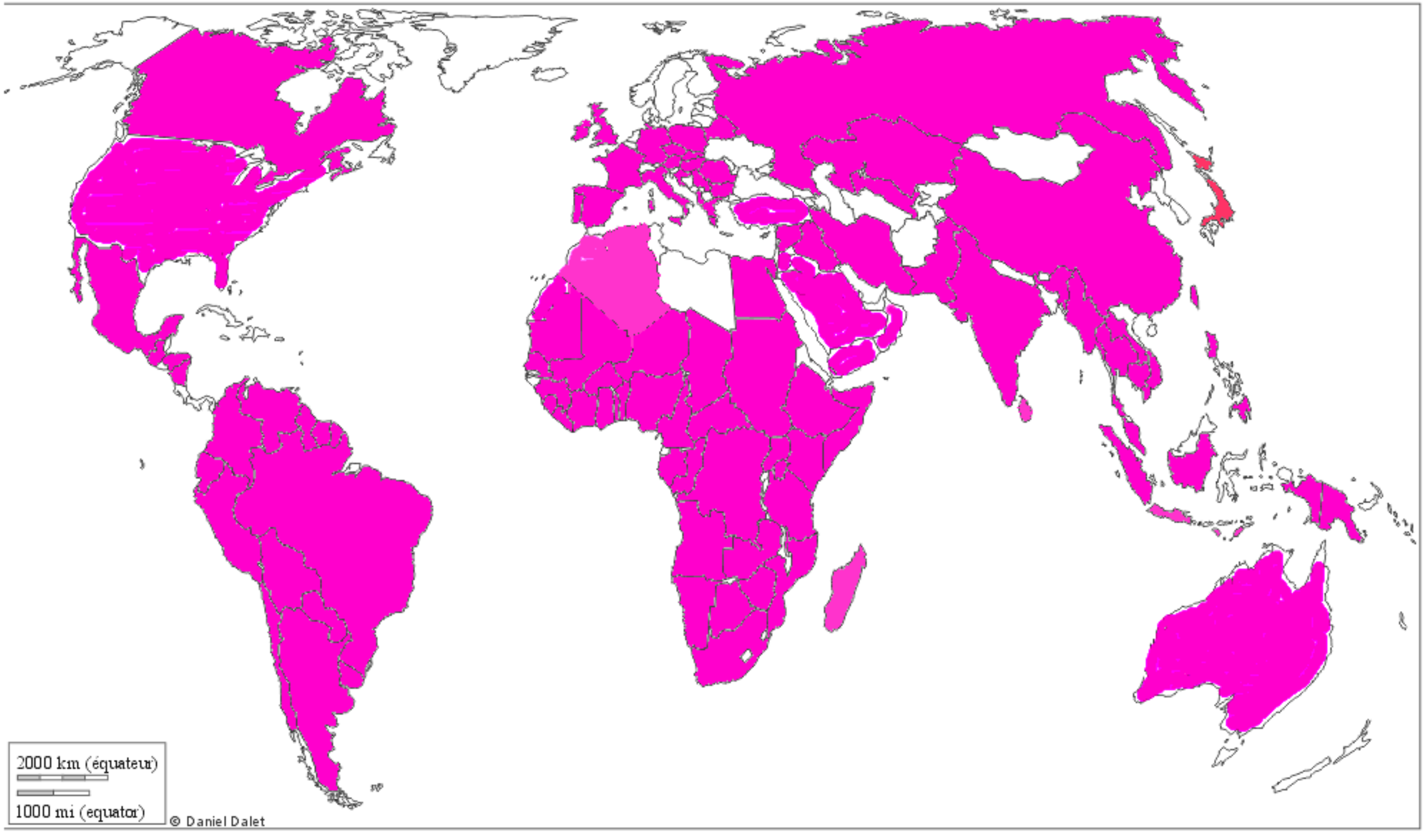
2) (Na,K,Ca)-rock-based geopolymer cement

and

one industrial hardener based on geology

(Na,K,Ca)-rock-based geopolymer cement (iron rich)

World-wide raw material for ferro-sialate geopolymer



State of the Geopolymer R&D 2014

1) Geopolymer science

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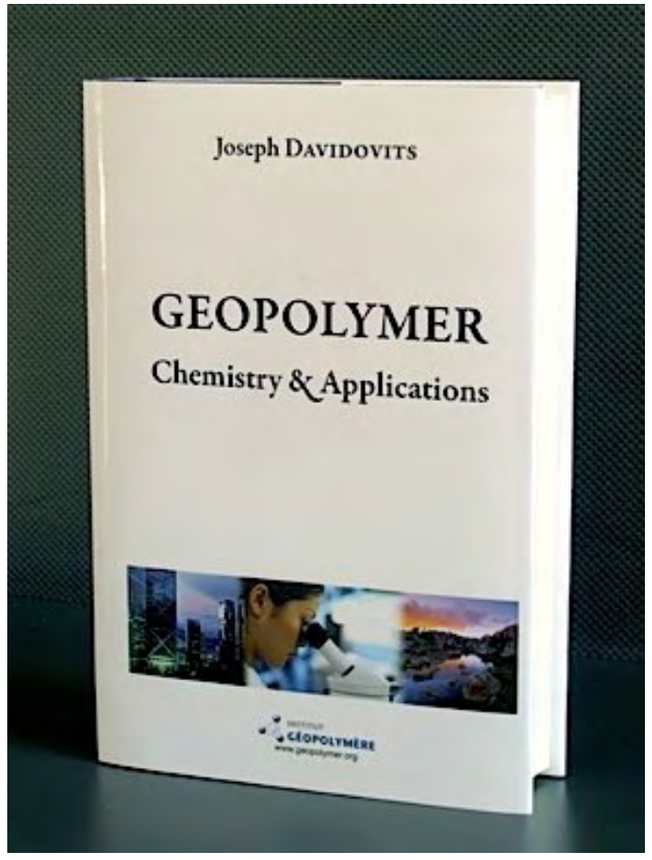
Geopolymer Science and Roman Cement

Chapter 17

Long term durability

Archaeological analogues



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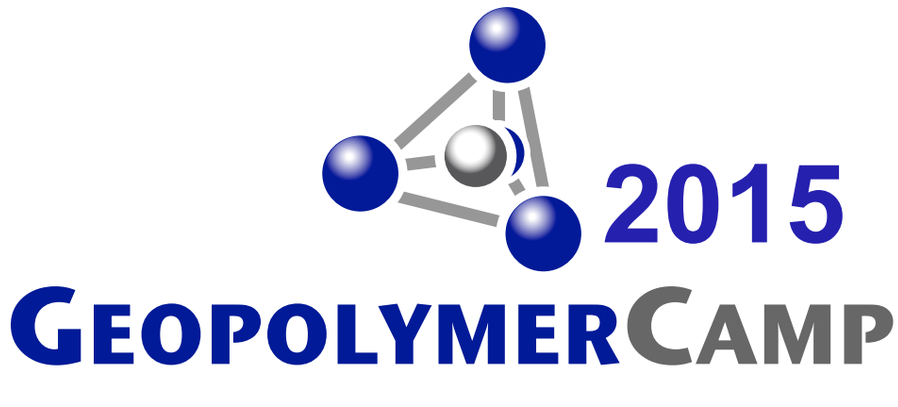

Joseph Davidovits